WEST DAVIS CORRIDOR

Comment 941 (continued)

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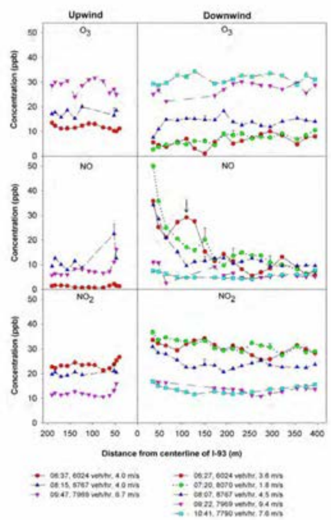

Fig. 6. Spatial and temporal variation of O_3, NO, and NO_2 along transects perpendicular to I-93. Legend shows vehicles per hour on I-93 (both directions) and average hourly wind speed. Error bars (one SD) are shown at locations where the AML stopped briefly and multiple measurements were made. Spike in 06:27 NO profile (indicated with arrow) likely represents the plume from a vehicle passing nearby the AML; spikes immediately upwind of the highway were likely due to traffic on Rt. 38.

upwind and downwind of the highway (Fig. 6). This strongly suggests that mixing with air from aloft was the dominant source of O_3. Overlying air layers generally contain low levels of PNC, CO_2 and NO_X, so concentrations of these pollutants are expected to decrease at ground level after the surface boundary layer mixes. However, the opposite is true for O_3: air layers aloft generally contain elevated levels of O_3 (Trainer et al., 1987); thus, O_3 levels were expected to increase at ground level after sunrise. The relatively low O_3 levels measured near the highway – particularly in the 06:27, 07:20, and 08:07 downwind profiles – are likely attributable to reaction of O_3 with NO. NO_2 photolysis, which regenerates O_3, was too slow to overcome O_3 losses (Pinto et al., 2007). The post-sunrise increase in O_3 is likely due to the breakup of the stable boundary layer, which is caused by nocturnal surface temperature inversions. Vertical temperature data for Boston was not readily available; however, based on data from the Massachusetts Department of Environmental Protection's vertical temperature profiler in Stowe, MA, located about 40 km to the west of our study area, early-morning surface inversions were present on about ~20% of days from 21 December 2007 to 21 March 2008 (http://madis-data.noaa.gov/cap/profiler.jsp?options=full).

The downwind profiles for methanol show similar spatial and temporal variations to those exhibited by the other vehicle exhaust components (Fig. 3). Methanol concentrations downwind of I-93 were highest early in the morning when the winds were the lightest. Methanol is present in both vehicle exhaust and is a major component in windshield wiper fluid (Rogers et al., 2006). These emissions rapidly mix in ambient air and appear as a single source downwind from vehicles. The presence of methanol in windshield wiper fluids makes the methanol measurements sensitive and highly variable due to the presence of vehicles in the direct vicinity of the AML. The interference from local traffic is evident in Fig. 3 by the large spikes in the upwind profile.

The AVOC concentrations (the sum of the signals from benzene, toluene, xylene isomers, ethyl benzene and C_3-benzene isomers) remained relatively constant throughout the morning and exhibit only weak spatial and temporal variations (Fig. 3). The high temporal response (100 ms dwell per mass) limited the precision of these measurements. Similar to the methanol, highest downwind AVOC concentrations were observed when winds were lightest. The AVOC concentrations are generally consistent with previous measurements made in the Boston area by Baker et al. (2008), which suggest an ambient AVOC concentration of 0.4 ppb with an enrichment of 4 ppt AVOC/ppb excess CO. Our measurements indicate that CO levels were enhanced by ~200 ppb above background (results not shown), suggesting an AVOC concentration of ~1.2 ppb, which is in good agreement with that shown in Fig. 3.

3.4 Spatial and temporal variation of particle composition measurements

Nitrate and sulfate aerosol concentrations (Fig. 7) were relatively low ($<1\ \mu g/m^3$) throughout the morning, and the profiles showed little spatial variation with distance from the highway. This was expected because vehicles are not significant direct emitters of nitrate aerosol, and the mandated use of ultra low sulfur diesel fuel (maximum sulfur content 15 ppm) leads to very low emissions of aerosol sulfate. The overall decrease in the levels of sulfate aerosol throughout the morning is attributable to the increase in surface boundary layer height. The increase in nitrate levels over the same period – except for the 10:41 downwind profile – likely reflects

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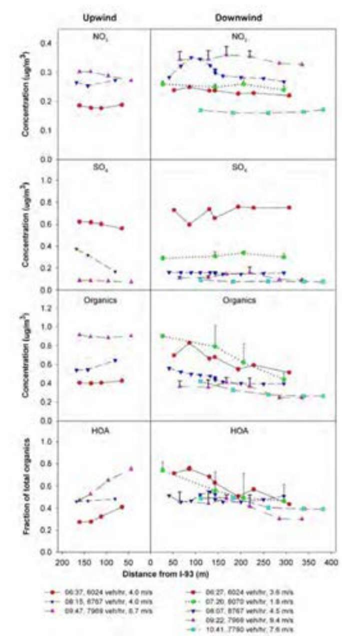

Fig. 7. Spatial and temporal variation of NO_3^-, SO_4^{2-}, organic aerosol and fraction hydrocarbon-like organic aerosol (HOA) along transects perpendicular to I-93. Legend shows vehicles per hour on I-93 (both directions) and average hourly wind speed. Error bars (one SD) are shown at locations where the AML stopped briefly and multiple measurements were made. The spike in the 07:20 and 09:47 organic aerosol profiles likely represent the plumes from vehicles passing nearby the AML.

photooxidation of background NO_X. Because the time scale for photooxidation of NO_X to nitrate is relatively long compared to downwind transport (Sander et al., 2006), it is likely that photooxidation of freshly-emitted NO_X from I-93 does not explain the increase in nitrate aerosol levels. Although the AMS is not sensitive to <30 nm particles and it is thus likely that our nitrate and sulfate aerosol concentration measurements underestimated the total, we do not believe this significantly impacts our conclusions.

The concentrations of organic aerosol were relatively low ($<1.4\ \mu g/m^3$) throughout the morning (Fig. 7). The downwind profiles <100 m from the highway showed the expected temporal variation, similar to that observed with PNC and NO (Fig. 3). At >100 m upwind there appeared to be local contributions of organic aerosol, particularly in the 08:15 and 09:47 profiles. Concentration differences between the 06:27-downwind and 06:37-upwind profiles are likely explained by high amounts of fresh highway emissions in the downwind profile. As in other urban areas (e.g., Zhang et al., 2007), two dominant organic components – hydrocarbon-like organic aerosol (HOA) and oxidized organic aerosol (OOA; approximated as the difference between the total organic aerosol mass and HOA mass) – accounted for 98% of the observed organic aerosol mass. The HOA component generally correlates well with tracers of vehicle emission (i.e., BC, CO, NO_X) indicating it has a dominant contribution from fresh vehicle emissions; the oxidized nature of the OOA component reflects photochemically-aged urban aerosol (Cangaratna et al., 2007; Zhang et al., 2007).

3.5 Significance

The results of this study have significance for near-highway air pollution characterization and exposure assessment. The results show that pollutant levels change rapidly as a function of atmospheric mixing conditions and chemical reactions over short distances near highways. We observed that the levels of primary pollutants (UFP and NO_X) were highest under light winds during pre-sunrise hours, and that following sunrise pollutant levels decreased rapidly both near the highway and downwind as the mixing height rose and wind speeds increased (Fig. 8). We also observed that the levels of reactive pollutants, such as O_3 and NO, change rapidly over short distances in the near highway zone (Fig. 6). These rapid temporal and fine-grain spatial changes in pollutant levels highlight the need for rapid-response instruments housed in mobile monitoring platforms to characterize near-highway air pollution gradients.

The high variability of near-highway pollution levels – particularly UFP – poses a challenge for exposure assessment. Assignment of air pollution exposure generally involves some degree of exposure misclassification; however, for UFP this problem is expected to be elevated compared to pollutants that demonstrate less geographic variation (e.g., $PM_{2.5}$ and black carbon). This may partly explain the paucity of epidemiologic studies of UFP. Indeed, most studies of human health effects and PM have focused on $PM_{2.5}$, PM_{10}, black carbon or elemental carbon (see reviews in Hoek et al., 2009; Knol et al., 2009). These studies typically assign annual average exposure at residential addresses using

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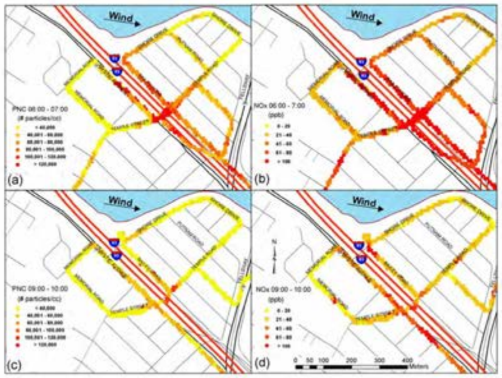

Fig. 8. Spatial distribution of particle number concentration (7–1000 nm) (**a** and **c**) and NO_x concentration (**b** and **d**) measured between 06:00–07:00 and between 09:00–10:00.

measured levels at nearby fixed monitors or interpolation between multiple fixed monitors. For $PM_{2.5}$, which varies relatively gradually across time and space, the error in exposure assessment introduced by movement of people (e.g., from their homes to where they work or go to school), results in only a limited amount of exposure misclassification. However, for pollutants like UFP that vary more substantially, the error is expected to be larger, perhaps large enough to compromise tests of association with health if exposure assessment approaches similar to $PM_{2.5}$ studies are applied. This suggests that knowledge of short-term temporal and fine-grain spatial resolution of UFP is necessary in studies testing associations between UFP exposure and health outcomes. Further, high resolution pollutant data will need to be weighted by time-activity information in order to assign reasonably accurate exposures to individuals. Given our results here and those of others (e.g., studies cited in Table 1), geographic scaling on the order of tens of meters and time resolution on the order of hourly are needed to capture the rapid changes in near-highway pollutant levels with distance. Also, because meteorological and highway traffic conditions change on multiple time scales, it is necessary to perform monitoring throughout the day on different days and in different seasons to characterize the full range of variability and thereby allow more complete exposure assessments.

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Exhibit E

Comment 941 (continued)

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Chapter 9

Near Roadway Exposure and Ultrafine Particles

South Coast Air Quality Management District

Cleaning the air that we breathe...

AQMD

Comment 941 (continued)

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32.11.2A

CHAPTER 9

NEAR ROADWAY EXPOSURE AND ULTRAFINE PARTICLES

Comment 941 (continued)

Response Section in Chapter 32 ➥

INTRODUCTION

There is growing concern about the potential health effects as caused by exposure for people living near major roadways to criteria pollutants and air toxics emitted from both gasoline and diesel vehicles (HEI, 2010). Recent toxicological and epidemiological studies have identified living near major roadways as a risk factor for respiratory and cardiovascular problems and other health related issues including: asthma and allergic diseases, reduced lung function and growth, low birth weight and pre-term newborns, lung cancer and premature death (Brugge et al., 2007; Kan et al., 2008; Balmes et al., 2009; Jerrett et al., 2009; Andersen et al., 2010; Hoek et al., 2010).

Motor-vehicle emissions consist of a complex mixture of particulate and gaseous pollutants such as fine particulate matter (PM2.5; particles with a diameter less than 2.5 µm), ultrafine particles (UFPs; diameter < 0.1 µm), metals, organic material, black carbon (BC), volatile organic compounds (VOC), nitrogen oxides (NOx; mostly NO and NO_2) and carbon monoxide (CO). While PM2.5 and NO_2 are currently regulated as criteria pollutants, UFPs have been shown to be toxic and have health impacts, but are not specifically regulated.

In 1998, the California Air Resources Board (CARB) classified diesel exhaust PM as a toxic air contaminant, citing its potential to cause cancer and other health problems. The U.S. EPA concluded that long-term exposure to diesel engine exhaust is likely to pose a lung cancer hazard to humans and can also contribute to other acute and chronic health effects.[1] The International Agency for Research on Cancer (IARC), part of the World Health Organization, recently classified diesel exhaust as a human carcinogen (Benbrahim-Tallaa et al., 2012). A recent study conducted by the District suggested that exposure to diesel PM is the major contributor to the remaining air toxics cancer risk in the South Coast Air Basin (Basin), accounting on average for about 84% of the carcinogenic risk attributable to air pollutants (MATES III; AQMD, 2008).[2]

While substantial effort has been made to characterize the health risks associated with exposure to diesel PM, information about the health impacts of UFPs is just now emerging. These very minute particles (consisting primarily of organic material, soot,

[1] http://www.epa.gov/ttn/atw/dieselfinal.pdf
[2] http://www.aqmd.gov/prdas/matesIII/matesIII.html

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and trace elements) have a different chemical composition than the larger PM fractions (PM2.5 and PM_{10}). Due to their small size, UFPs can penetrate deeply into the human respiratory tract, into the blood stream, and be transported to other critical organs such as the heart and brain. Furthermore, their large surface area may provide a mechanism for delivering potentially toxic adsorbed material into the lung and other organs. This penetration capability is suspected to have human health implications because UFPs' toxic components may initiate or facilitate biological processes that may lead to adverse effects to the heart, lung, and other organs (HEI, 2010).

UFPs are emitted from almost every fuel combustion process, including diesel, gasoline, and jet engines, as well as external combustion processes such as wood burning. Consequently, there is growing concern that people living in close proximity to highly trafficked roadways and other sources of combustion-related pollutants (e.g. airports and rail yards) may be exposed to significant levels of UFPs and other air toxics.

Over the last decade, substantial efforts have been made to better characterize the physical and chemical properties of UFPs and their potential impact on people living in close proximity to roadways and other emissions sources. Two areas of research have received particular attention:

- On-roadways, near-roadways, and in-vehicle measurements: UFP emissions from motor vehicles are not static after leaving the tailpipe and undergo physical transformation and chemical reactions in the atmosphere as they are transported away from the source. In order to study the dynamic nature of UFP formation, evolution and transport, as well as their physical and chemical properties, and human exposure, UFP measurements have been taken at the tailpipe, at different distances from the edge of roadways, and inside vehicles.
- Effect of UFP reduction technologies: As modern engines and emissions controls continue to evolve, the mass of combustion-related PM has been dramatically reduced through sophisticated control of combustion conditions, introduction of ultra low sulfur diesel fuel, and the application of after-treatment control technologies such as diesel particulate filters (DPFs). In some cases, emission controls designed for PM mass have facilitated the formation of a greater number of UFPs. However, properly designed emission control technologies can limit the formation and emission of UFP as well as PM mass.

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From a regulatory perspective, the U.S. focus has been on reducing the mass of PM emitted in the ambient air. However, UFPs contribute a very small portion of the overall atmospheric particle mass concentration. Thus, there has been growing interest over the last two decades to study, understand, and regulate the size and number of particles found in PM generated from diesel and other combustion engines. Partly because light-duty diesel vehicles are very common in European countries, the European Union has already adopted standards that phase in particle number limits for passenger car and light-duty vehicle emissions. However, there are still concerns related to the health impacts of non-solid organic UFP components that are not addressed by the European solid particle number standard.

Recently, CARB staff prepared a preliminary discussion paper on proposed amendments to California's Low-Emission Vehicle (LEV III) Regulations, to address UFP emissions from light-duty motor vehicles by promoting a solid particle number based PM compliance strategy (CARB, 2010)[3]. CARB staff ultimately decided that the complexity of the issues warranted further study and understanding before proceeding. Although the District has limited authority to regulate mobile source pollution in the near-roadway environment, District staff has implemented a variety of measures to assess and reduce the health impacts of near-roadway emissions on local communities. The District continues to demonstrate and incentivize the deployment of zero/near-zero emission technology, has implemented numerous installations of high-efficiency air filtration in schools, and conducts outreach and education on near-roadway health impacts. Furthermore, on July 1, 2012 the District began the next Multiple Air Toxics Exposure Study (MATES IV) to characterize the carcinogenic risk from exposure to air toxics in the Basin. A new focus of MATES IV will be the inclusion of measurements of UFP and BC concentrations across the Basin, and near specific combustion sources (e.g. airports, freeways, rail yards, busy intersections, and warehouse operations) to evaluate the long- and short-term exposures to these pollutants.

This chapter of the AQMP first presents background information on UFPs and other important air pollutants emitted from motor vehicles. Next, recent results from ambient measurement studies conducted near traffic sources, on roadways, and inside vehicles are reviewed, followed by an explanation of the current state of knowledge on the health effects caused by UFPs and near-roadway exposure to pollutants.

[3] http://www.arb.ca.gov/msprog/levprog/leviii/meetings/051810/pm_disc_paper-v6.pdf

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Finally, potential control, mitigation, and policy strategies for limiting such exposures are discussed with recommendations for future actions to address this emerging and important topic.

ULTRAFINE PARTICLES

Formation and Transport

UFPs are emitted from both natural and anthropogenic sources, although in most urban environments vehicular fossil fuel combustion constitutes the major contributing source. The terms UFPs and nanoparticles (NP; diameter < 0.05 μm) are often used interchangeably, and the definitions of each generally vary with the study or application. While PM2.5 dominates the mass distribution of atmospheric particles, UFPs account for about 90% of the total particle number (Stanier et al., 2004a and Zhang et al., 2004). For this reason, their concentration is usually expressed in terms of total particle count (i.e. # per cubic centimeter of sampled air, or $\#/cm^3$), even though a small fraction of the particles being counted may be above 100 nm.

In the late 1990s, pioneering research by the University of Minnesota (Kittelson, 1998) made significant new progress by identifying three size categories for particles found in diesel engine emissions: 1) coarse mode (1 μm < d < 10 μm), 2) accumulation mode (~ 0.05 μm < d < 1 μm), and 3) nuclei mode (d < 0.05 μm). As shown in Figure 9-1, UFPs (d < 0.1 μm) and NPs in particular dominate the total number concentration (blue line).

Today we know that, typically, three UFP size modes appear in the exhaust of motor vehicles:

- Narrow nucleation mode at around 10 nm that corresponds to nucleated particles that have grown by condensation of gaseous precursors. It is mostly comprised of sulfate particles and semi-volatile organic compounds (SVOCs).
- Larger nucleation mode at around 20 to 30 nm which also contains sulfate particles and SVOCs.
- Accumulation mode at around 60 nm that results from the combustion process and that mostly includes soot and non-volatile organic compounds, but also sulfate and SVOCs. This mode is primarily associated with diesel exhaust.

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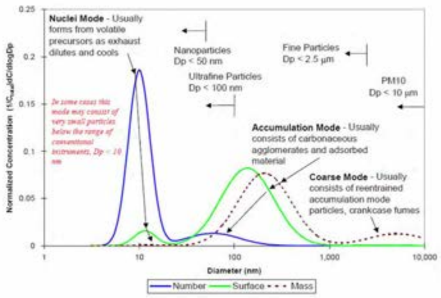

FIGURE 9-1

Typical Particle Size Distribution for Uncontrolled Diesel Emissions (Kittelson, 1998)

Particles from motor vehicle emissions can be divided into two broad categories, depending on the location of their formation:

- Primary combustion particles: formed in the engine or tailpipe, they are mostly sub-micrometer agglomerates of solid phase carbonaceous material ranging in size from 30 to 500 nm. These particles may also contain metallic ash (from lubricating oil additives and from engine wear), adsorbed or condensed hydrocarbons, and sulfur compounds (Morawska et al., 2008).

- Near-tailpipe UFPs: as the hot exhaust gases are expelled from the tailpipe, they quickly cool and condense on existing particles or nucleate to form large numbers of very small particles in the air. They consist mainly of hydrocarbons and hydrated sulfuric acid, are generally 30 nm or less in diameter and are most commonly observed near busy freeways, especially those where a large fraction of heavy-duty diesel vehicles is present (Westerdahl et al., 2005; Ntziachristos et al., 2007; eskinen and Ronkko, 2010). These particles are formed very quickly and are distinct from UFPs derived from photochemical nucleation processes occurring in the atmosphere further away from the source (Stanier et al., 2004b).

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Once released into the atmosphere, UFPs undergo dilution with ambient air and are subject to chemical reactions and physical processes such as evaporation, condensation, and coagulation. Thus, particles measured away from roadways and other emission sources generally have different characteristics than those measured immediately after formation. Wind speed and direction, precipitation, relative humidity, and temperature are the main meteorological factors affecting UFP transport.

Ambient Diurnal and Seasonal Variations

In ambient urban environments, strong diurnal variations in UFP concentration have been reported in many studies and shown to closely follow the temporal variation in traffic density, with the highest levels observed on weekdays during rush hours (Hussein et al., 2004; Morawska et al., 2008; AQMD, 2012)[4]. Typically, weekdays are characterized by two peaks in UFPs, one early in the morning and another in the afternoon coinciding with traffic rush hours. A wider mid-day peak is usually observed on weekends. Photochemical particle formation also contributes to increasing the afternoon number concentration of UFPs, especially in the summer.

Several meteorological factors contribute to the seasonal variability in the concentration of atmospheric PM and UFPs; these include:

- Lower mixing layer height and greater atmospheric stability in winter, which tend to increase particle levels by not allowing for vertical mixing in the atmosphere.

- Lower winter temperature, which leads to increased nucleation of volatile combustion products, particularly during morning rush hours.

- Higher photochemical activity in the summer, which favors photochemical particle formation.

It should be noted that the effects of these meteorological factors on particle concentration are more pronounced in areas where there are significant meteorological differences between seasons. Pirjola et al. (2006) and Virtanen et al. (2006) showed that the average UFP concentrations in winter in Finland were 2–3 times higher than in the summer, with the highest values observed in February. The highest and lowest monthly average UFP concentrations in Pittsburgh (U.S.A.) reported by Zhang et al. (2004) were measured in December and July, respectively.

[4] http://www.aqmd.gov/tao/AQ-Reports/I710Fwy_Study.pdf

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In the wintertime most of the factors leading to an increase in particle concentration tend to occur early in the morning (i.e. rush hour traffic, low mixing height, low wind speed and temperature). Summer minima are usually associated with increased ambient temperature (which does not favor the nucleation process), although increased photochemical activity can lead to new UFP formation.

Concentration Levels in Different Environments

Morawska et al. (2008) compared particle concentration levels reported for different environments including: road tunnel, on-road, road-side, street canyon, urban, urban background, rural, and clean background (Figure 9-2). The mean and median values for each category were calculated using available literature data and are shown below to illustrate the typical atmospheric variability in UFP number concentration measurements.

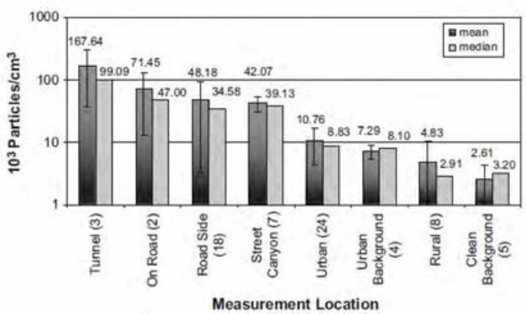

FIGURE 9-2

Mean and Median Particle Number Concentrations for Different Environments

In brackets are the numbers of sites for each environment used to calculate the mean and median UFP values. Vertical lines represent standard deviations (from Morawska et al., 2008)

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Substantially higher peak particle number levels are expected in each environment over shorter time periods (e.g. seconds to minutes), and in close proximity to specific sources such as roadways and airports. For example, in a recent study conducted by the District near the Santa Monica Airport (SMO; a general aviation airport), 1-min average UFP levels as high as 2,600,000 #/cm3 were measured 35 m downwind of the runway during jet aircraft take-off (AQMD, 2011)5. One-minute maxima between 1,500,000 and 2,000,000 #/cm3 (also associated with jet aircraft departures) were observed 100 m downwind of the runway in the backyard of a local residence.

Chemical Composition

Comprehensive knowledge of the chemical composition of UFPs in ambient air is still not available, mostly because of the small amount of mass available for analysis, and because most studies have been conducted using different measurement protocols, sampled particles in different size ranges, and focused on different aspects of their chemical composition (Morawska et al., 2008). However, it is known that engine emissions include sulfur dioxide (SO_2) or sulfur trioxide (SO_3) and NOx, and that nucleation of these gaseous species into sulfate and nitrate particles is an important mechanism for increasing particle formation near traffic sites.

A few studies have investigated the composition of UFPs in urban environments. Kuhn et al. (2005) showed that UFP samples collected in downtown Pittsburgh were mostly comprised of organic matter (45 to 55% by weight) and salts of ammonium and sulfate (35 to 40%). In a study conducted at two Los Angeles sites (urban and inland), Sardar et al. (2005) found that organic carbon (OC; the amount of carbon present in the collected organic material) ranged from 32 to 69% (by weight), elemental carbon (EC; an indicator of diesel PM and closely related to BC) from 1 to 34%, sulfate from 0 to 24% and nitrate from 0 to 4%. In these and other cases, organic material was found to comprise the larger fraction of UFP by mass especially in the summer, when photochemical formation of organic aerosol is higher. UFP chemistry, including elemental composition, was investigated by Pakkanen et al. (2001) at two sites (urban and rural) in Helsinki (Finland). The most important trace elements at both sites were Ca, Na, Fe, K and Zn (present in higher concentrations), and Ni, V, Cu, and Pb ("heavy metals"). These measured species accounted for less than 1% of the total UFP mass and their presence was probably related to local combustion sources, possibly traffic exhaust, and combustion of heavy fuel oil. Overall, the

[5] http://www.aqmd.gov/tao/AQ-Reports/Supplement_GA_Report.pdf

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chemical composition of UFPs differs significantly from place to place and depends on the types of local sources and their relative contributions.

Measurement Methods

A basic knowledge of the instruments used for monitoring UFPs is critical as the resulting measurements are dependent on the method and measurement principle used. Since there is no "standard" measurement technique or calibration standard by which different instruments can be evaluated and compared, UFP measurements are somewhat operationally defined. Below is a list of the most common instruments that have been used to monitor the mass and number concentration and size distribution of UFPs in the atmosphere and in exhaust streams. For a more comprehensive discussion on the issues associated with measuring UFPs see Maricq and Maldonado (2010) and Robinson et al. (2010).

- Condensation Particle Counter (CPC): it provides the total number concentration of particles above a lower size limit (~3 -20 nm, depending on make and model) in real-time. UFPs are grown through condensation in a controlled super-saturation environment to larger sizes and then measured (counted) using a photodetector. Alcohol or water are usually used as condensing liquids. Although CPCs are the most widely used instruments in most applications, they do not provide any information on the original size of the particles counted.

- Scanning Mobility Particle Sizer (SMPS): particle counters can also be used in conjunction with electrostatic classifiers (used to separate airborne particles according to their size) to characterize the particle size distribution of UFPs. Typically, SMPSs provide size distribution data in almost real-time for particles as small as 10 nm.

- Electrical Low-Pressure Impactors (ELPI): this instrument provides real-time number weighted size distributions in the particle diameter range of 30 to 10,000 nm. ELPIs are very sensitive instruments and measure ambient aerosol concentrations and size distributions. They can be used to measure particle charge distribution in real-time, and also allow for particle collection and direct mass measurements.

- Engine Exhaust Particle Sizer (EEPS): it measures particle size distributions in real time and covers a range from ~3 to 500 nm. It was designed specifically to measure particles emitted from internal combustion engines and motor vehicles,

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but newer versions are designed for ambient applications. Its fast response (e.g. ~10 Hz data collection) allows for the measurement of transient signals, but also tracks well with the CPC concentrations and SMPS size distributions.

- Micro Orifice Uniform Deposition Impactor (MOUDI): it provides integrated mass-based size distribution measurements covering particle sizes from ~56 to10000 nm. Nano MOUDIs are used for smaller particle size ranges (i.e. ~ 10 to 56 nm). Particle samples collected using a MOUDI can also be analyzed for chemical composition in the lab.

Most of the instruments outlined above have been used in engine/vehicle emission testing. Ambient air monitoring of UFPs is also performed using some of the same instrumentation, especially CPCs and SMPSs. It should be noted that different make/model CPCs are characterized by different particle size ranges, sampling flow rates, optical detection techniques, and other instrumental characteristics and, thus, they may provide significantly different results. Therefore, UFP number measurements from different studies should be compared with caution. The District has worked in collaboration with the University of California, Los Angeles (UCLA), CARB, and with various CPC manufacturers to study intra- and inter-model variations in total number concentration measurements taken with several CPC units (Lee et al., submitted).

OTHER NEAR-ROADWAY POLLUTANTS

The majority of air monitoring studies conducted near- and on-roadways in the past decade has focused not only on the measurements of UFPs, but also on the emissions of more traditional and well-studied pollutants. These include:

- Carbon monoxide (CO): ambient concentrations of this pollutant have declined through the adoption of emission control technologies and regulations. However, motor vehicles (especially light-duty, gasoline-powered vehicles) remain the primary source of CO at most locations.

- Oxides of nitrogen (NOx): although all motor vehicles emit NOx, the majority of current on-road NOx emissions occur from diesel vehicles. In terms of primary emissions, the majority of NOx exhaust is in the form of NO. NO_2 is the focus of concern in terms of health effects and quickly forms by a photochemical reaction from the oxidation of NO. Primary NOx emissions from heavy-duty diesel engines

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with after-treatment devices may contain a greater percentage of NO_2 relative to NO.

- Particulate matter (PM): suspended particles are generally divided in UFP (already discussed), PM2.5 and PM_{10}. Significant near-roadway sources of PM mass include direct emissions from motor vehicle combustion (mostly PM2.5), brake and tire wear, and re-suspension of dust from the road surface (mostly PM_{10} and larger). The atmospheric concentration of PM2.5 is mostly affected by contributions from regional sources, and the impact of direct emissions from motor vehicles is generally small in near-roadway environments.
- Volatile organic compounds (VOCs) and carbonyls: these gaseous air toxics are emitted from both natural and anthropogenic sources (including motor vehicles), are involved in the photochemical formation of atmospheric O_3, and some of them have been associated with both short- and long-term toxic health effects. Typical VOCs of concern for near-road monitoring include benzene, toluene, ethylbenzene, xylenes, styrene, formaldehyde, acetaldehyde, and acrolein, all of which are also toxic air contaminants.
- Black (or elemental) carbon (BC or EC): often referred to as "soot," BC (or EC) is a common constituent emitted from motor vehicles. Both BC and EC are operationally defined and represent the black, graphitic-containing portion of PM. Although BC and EC are often associated with emissions from heavy-duty diesel engines, a portion of all motor vehicle combustion emissions contains these constituents. A recent study conducted by Liggio et al. (2012) has shown that BC emissions from light-duty-gasoline-vehicles may be at least a factor of 2 to 9 times higher than previously thought. Other sources of BC exist in urban areas, but emissions from motor vehicles, primarily diesel trucks, usually dominate these sources in near-roadway environments.

Most near-road studies showed good correlation among the pollutants listed above (with the exception of PM2.5, whose atmospheric concentration is mostly influenced by regional sources), indicating a common traffic origin (Zhu et al., 2002a,b; Sardar et al., 2005; Hagler et al., 2010). In particular, BC is often very well correlated with UFP concentrations in urban air, given that both are emitted from motor vehicles and the larger relative BC content found in the ultrafine particle size range.

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AMBIENT MEASUREMENTS

Near-Roadway Studies

The majority of all near-roadway studies conducted to date have focused on the influence of proximity to roadways on outdoor (residential) and indoor exposure to air pollutants. In virtually all of these works, it was found that the outdoor concentrations of primary pollutants emitted from motor-vehicle emissions (UFP and BC in particular) were more strongly correlated with distance from roadways than the outdoor concentrations of species dominated by atmospheric formation or other regional sources (e.g. PM2.5). Measured concentrations of these primary pollutants were typically highest in close proximity to a roadway and decreased exponentially with increasing distance from (and downwind of) the source. In a study conducted in the Los Angeles area in the daytime, Zhu et al. (2002a) found that the concentrations of CO, BC, and UFPs were highest in the immediate vicinity (17 m) of the I-710 (a freeway highly influenced by heavy-duty diesel trucks), and decreased exponentially to upwind background levels after about 300 m (Figure 9-3a). A companion study was carried out next to the I-405 freeway (dominated by gasoline vehicle traffic) with similar results (Zhu et al. 2002b) (Figure 9-3b).[6] As discussed earlier, the dynamic pollutant mix evolves during transport from the road: nucleation leads to formation of new particles very soon after emission, followed by their growth by condensation, diffusion to surfaces, evaporation and coagulation. Therefore, at the edge of a roadway, particle concentrations are dominated by the smallest particles (in the 6-10 nm range), with the peak in distribution shifting to the larger sizes at greater distances.

[6] For each air pollutant, upwind and downwind concentrations were normalized to the highest level measured at the edge of the freeway and expressed as relative values (i.e. 0 to 1)

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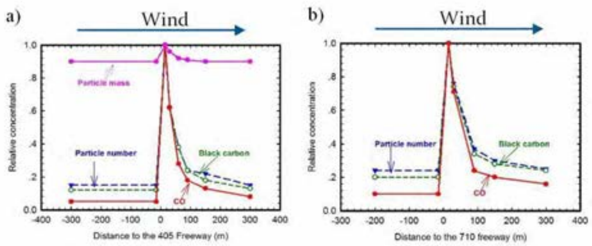

FIGURE 9-3

Relative Black Carbon (BC), Carbon Monoxide (CO), Particle Number (a surrogate for ultrafine particles or UFP), and Particle Mass (PM2.5) Concentrations Upwind and Downwind of the I-405 (a) and I-710 (b) Freeways (from Zhu et al., 2002a; 2002b).

Note that PM2.5 was not measured at the I-710.

Measurements conducted in communities adjacent to the Ports of Los Angeles and Long Beach revealed that concentrations of UFP, BC, and NO_2 (mostly from heavy-duty diesel trucks) were frequently elevated two to five times within 150 m downwind of freeways (compared to more than 150 m) and up to two times within 150 m downwind of arterial roads with significant amounts of diesel traffic (Kozawa et al. 2009). In the winter and summer of 2009 the District conducted an intensive study in the vicinity of the I-710 to characterize the spatial and temporal variations of motor vehicle emissions, and their potential impact on the surrounding communities (AQMD, 2012)[7]. Emissions 15 m downwind of the freeway were found to be enriched in BC, UFP, and NO_x, combustion pollutants emitted directly from gasoline and, especially, diesel vehicles. The atmospheric concentration of PM2.5 mass and VOCs was not as heavily impacted by proximity to the I-710.

During a recent daytime study conducted in New York City before, during, and after vehicle traffic was excluded from a major street (Park. Ave.), Whitlow et al. (2011) showed that the curbside airborne PM2.5 level always peaked in the morning regardless of traffic conditions, while UFP number concentration was 58% lower

[7] http://www.aqmd.gov/tao/AQ-Reports/I710Fwy_Study.pdf

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during mornings without traffic. Furthermore, UFP count varied linearly with traffic flow, while PM2.5 spiked sharply in response to random traffic events that were weakly correlated with the traffic signal cycle. As expected, UFP concentrations decayed exponentially with distance from the street with unrestricted traffic flow, reaching background levels within 100 m of the source. It is likely that background concentrations of most motor vehicle related pollutants in large urban areas like New York City are more elevated than those found elsewhere.

Karner et al., (2010) summarized data reported in 41 roadside monitoring studies (all conducted during daytime) and found that almost all combustion-related pollutants decay to background by 115-570 m from the edge of road. Changes in pollutant concentrations with increasing distance from the road fell into one of three groups: 1) at least a 50% decrease in peak/edge-of-road concentration by 150 m, followed by consistent but gradual decay toward background (e.g. CO and UFP); 2) consistent decay or change over the entire distance range (e.g. benzene and NO_2); and 3) little or no trend with distance (e.g. PM2.5 mass concentrations).

It should be noted that nighttime conditions can lengthen the distance at which near-road pollutant concentrations decay to background. For instance, Hu et al. (2009) observed a wider area of air pollutant impact downwind of the I-10 freeway during pre-sunrise hours. In particular, UFP concentrations peaked immediately downwind of the I-10 and reached background levels only after a distance of about 2600 m (Figure 9-4).[8] Other combustion related pollutants, such as NO and particle-bound polycyclic aromatic hydrocarbons (p-PAHs), exhibited similar long-distance downwind concentration gradients. The authors associated these elevated pre-sunrise concentrations over a wide area with a nocturnal surface temperature inversion, low wind speeds, and high relative humidity. It should be noted that, occasionally, nighttime near-road UFP number concentrations exceeded daytime conditions, despite reduced traffic volumes.

Further work is needed to integrate daytime and nighttime findings and to assess their relative importance given daytime and nighttime differences in traffic activity, near-road pollutant concentrations, and factors affecting human exposure.

[8] Upwind and downwind UFP concentrations were normalized to the highest level measured at the edge of the freeway and expressed as relative values (i.e. 0 to 1)

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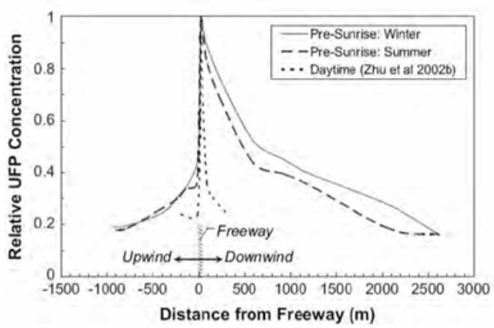

FIGURE 9-4

Relative Averaged UFP Concentrations and Gradients During Pre-sunrise Hours along the I-10 (Hu et al., 2009) and the I-710 Freeways (Zhu et al., 2002b)

In the last few years, new powerful instruments have been developed to characterize the physical and chemical characteristics of freshly emitted aerosols in real time. For example, Sun et al. (2012) used a High-Resolution Time-of-Flight Aerosol Mass Spectrometer to study the mass concentrations and chemical composition of sub-micron aerosol species (PM_1) in the vicinity (30 m) of a major highway in New York City. The mass spectrometer data (taken at 1-min time resolution) was complemented by rapid measurements (down to 1 Hz) of particle number concentrations and size distributions. Overall, hydrocarbon-like organic (HOA) species dominated the composition of traffic-related PM_1 especially during periods of high traffic intensity. Significant enhancements in ultrafine organic aerosol mass and particle number concentrations were frequently observed in traffic plumes, suggesting that UFPs are dominated by HOA species from vehicle emissions near highways.

On-road Studies and In-Vehicle Exposure

Several studies have found that, while commuting, individuals are exposed to air toxic levels that are several times higher than the corresponding ambient concentrations measured at fixed near-roadway monitoring sites. Most of these on-road studies have been conducted using zero-emissions mobile platforms outfitted with real-time

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instruments to spatially characterize particle and gaseous pollutant concentrations. Fujita et al. (2003) found that concentrations of BC and NOx in Harbor communities of Wilmington, West Long Beach, and San Pedro (California) were about ten times higher on roadways than at regional air monitoring sites. Similarly, Westerdahl et al. (2005) showed that concentrations of UFP, NO, BC and CO on Los Angeles freeways were often ten times higher than those on residential streets.

Heavily impacted industrial communities are also characterized by increased on-road air pollutant concentrations. For example, elevated UFP, BC, and NO concentrations were observed across the residential neighborhood of Boyle Heights in Los Angeles (Hu et al. 2012). UFP concentrations were nearly uniform spatially, in contrast to other areas in the greater metropolitan area of Los Angeles where UFP concentrations exhibit strong gradients downwind of roadways. This was attributed to the presence of high heavy-duty traffic volumes on the freeways surrounding Boyle Heights, and substantial numbers of high-emitting vehicles on local surface streets. The high density of stop signs and lights, and short block lengths, requiring frequent acceleration of vehicles, may contribute to elevated UFP levels observed in this area.

Fruin et al. (2008) characterized air pollutant concentrations on Los Angeles freeways and arterial roads. On freeways, concentrations of UFPs, BC, NOx, and p-PAH were generated primarily by diesel emissions, despite the relatively low fraction (~6%) of diesel-powered vehicles. However, UFP concentrations on arterial roads appeared to be driven mainly by proximity to gasoline-fueled cars undergoing hard accelerations. Concentrations were roughly one-third of those on freeways. They concluded that 33 to 45% of total UFP exposure for Los Angeles residents occurs due to time spent traveling in vehicles. A previous study conducted by the same research group showed that time spent in vehicles contributes between 30 and 55% of Californian's total exposure to diesel PM (Fruin et al., 2004). The applicability of these estimates to other regions of the United States is largely unknown.

Due to the high air exchange rates (AERs) of moving cars/trucks, in-vehicle concentrations are typically close to roadway concentrations. Inside-to-outside UFP concentration ratios are best measured under realistic conditions because AERs and other factors influencing these ratios are determined by vehicle speed and ventilation preference, in addition to vehicle characteristics such as age. Two independent studies conducted in Southern California showed that in-cabin concentration of UFPs can be reduced substantially (i.e. up to ~85%) by turning the recirculation fan on (Zhu et al. 2007; Hudda et al. 2011). Evidence suggests that increased ventilation is also a key

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determinant of in-cabin UFP concentrations in buses, ferries, and rail modes (Knibbs et al., 2011). Where a vehicle is fitted with a cabin air filter, its particle removal efficiency is a key determinant of what proportion of on-road UFPs reach the cabin (Burtscher et al., 2008; Pui et al., 2008).

Important Factors Affecting Near-Roadway Measurements

The air quality monitoring studies described above measured elevated concentrations of UFPs and other combustion pollutants near roadways. However, most of these studies were conducted under different environmental conditions. In order to interpret results from these and future near-roadway activities and to better evaluate the risks associated with living in close proximity to highly trafficked freeways, it is important to consider all variables influencing the observed monitoring data. These may include:

- Traffic activity: parameters such as the total number of vehicles, the fleet mix (e.g., gasoline vs. diesel), and vehicle speeds affect the concentration of near-road pollutants. This information can usually be obtained from local transportation agencies or on the web.[9]

- Meteorological parameters: wind speed and direction, temperature, humidity, and atmospheric stability can be used to better evaluate the generation, transformation and transport of traffic-generated emissions and for interpreting near-road air quality data.

- Roadway type: proximity to busy freeways has generally been associated with an increase in atmospheric UFPs. However, most urban areas contain arterial roadways that experience regular increases in UFP levels, especially during morning and afternoon rush hours. Increased number of stop-and-go operations from traffic signals, longer idling times, and cold start conditions all contribute to increased UFP emissions.

- Roadway design: road grades create an increased load on vehicles ascending the grade, leading to increased exhaust emissions and potential tire wear, while vehicles descending the grade experience increased brake emissions. The presence of ramps, intersections, and lane merge locations can also lead to increased brake

[9] For example, see Caltrans' Performance Measurement System (PeMS); http://pems.dot.ca.gov

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wear emissions and idling vehicle conditions due to increased congestion (Baldouf et al., 2009).

- Roadside structures: the presence of roadside features such as noise barriers, trees, and buildings can change the dynamics of air pollutant dispersion downwind of a freeway. Results from two recent studies conducted in Raleigh, NC and in Los Angeles indicate that near-roadway concentrations of combustion particles (e.g. UFP and BC) and related gaseous co-pollutants (e.g. CO and NO_2) were lower where a noise barrier was present than in open terrain (Bowker et al., 2007 and Ning et al., 2010). However, a longer downwind distance was generally needed to reach background levels, indicating a larger impact zone of traffic emission sources. Noise barriers adjacent to a roadway may also inhibit air movements off the road, leading to elevated on-road pollutant concentrations (Bowker et al. 2007; Baldauf et al. 2008). The District has several ongoing research efforts to better evaluate the mitigation potential of various roadside features.

HEALTH EFFECTS

Ultrafine Particles

Short- and long-term exposure to particles produced from combustion processes have been associated with numerous adverse health effects in humans including various cardiovascular and respiratory diseases (Pope and Dockery, 2006). It has been hypothesized that the ultrafine portion of atmospheric PM may be responsible for the majority of the observed health effects (Brugge et al., 2007; Balmes et al., 2009; Jarrett et al., 2009; Hoek et al., 2010; Ljubimova et al., 2012). Thus, recent research studies have specifically focused on UFPs and their ability to be absorbed deeply into the lungs, move across cell membranes, and translocate into the bloodstream and other parts of the body. As noted in the preceding sections, the formation and subsequent evolution of UFPs is complex. They are formed and processed on the order of minutes, but their composition continues to change depending on intricate interactions in the exhaust stream and in ambient air. Thus, exposures will vary depending on location within the exhaust plume and with distance from the emission source.

The mechanisms linking UFP exposure to observed health impacts are still not completely understood, but one of the most plausible hypotheses is that many of the adverse health effects may derive from oxidative stress, initiated by the formation

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of reactive oxygen species (ROS) within affected cells. Work conducted at the University of California Los Angeles (UCLA) Southern California Particle Center in the past decade has demonstrated that because of their high OC and polycyclic aromatic hydrocarbon (PAH) content, UFPs have the highest potential to generate ROS and to induce oxidative stress in macrophages and epithelial cells (Li et al., 2003). This, in turn, may promote allergic inflammation in the lungs, the progression of atherosclerosis, and precipitation of acute cardiovascular responses ranging from increased blood pressure to myocardial infarction (Delfino et al., 2005; Araujo et al., 2008). From the analysis of summertime ambient PM samples collected near downtown Los Angeles in the morning and in the afternoon, Verma et al. (2009) showed that both primary (traffic dominated) and photochemically formed quasi-ultrafine particles (d < 250 nm) possess high reduction-oxidation activity. However, the latter particle type appeared to be more potent in terms of generating oxidative stress and leading to subsequent damage in cells. The semi-volatile component of quasi-ultrafine urban aerosols (mostly OC and PAHs) seems to be responsible for most of the oxidative potential of PM (Verma et al., 2011).

Recent works have examined the health consequences due to UFP exposure on the most susceptible part of the population such as elderly individuals, children and subjects with asthma and diabetes. For example, between 2005 and 2007 the University of California Irvine (UCI) led a multi-disciplinary project (i.e. Cardiovascular Health and Air Pollution Study or CHAPS) to study the health effects of environmental exposure to different PM fractions (including UFPs) in elderly retirees affected by coronary artery disease (Delfino et al. 2008; 2009). Results suggested that traffic-related emissions of primary OC, PAHs, and UFPs were associated with adverse cardio-respiratory responses including elevated blood pressure (Delfino et al., 2010) and increased risk of myocardial ischemia (Delfino et al., 2011).

Other studies tried to elucidate the link between inhalation of UFPs and cardiovascular responses in children and young adults. In most studies, healthy young subjects were exposed to filtered "particle-free" air or UFPs at rest and during exercise (e.g. Shah, et al. 2008; Zareba, et al. 2009; Samet, et al. 2009). Short-term exposure to UFPs did not cause marked changes to the electrocardiography (ECG) parameters, although acute exposure had mild inflammatory and prothrombotic responses. In a recent experiment conducted by Pope et al. (2011), healthy, non-smoking young adults were exposed a) to known amounts of PM2.5 (150-200 $\mu g/m^3$) from wood and coal combustion, and b) to uncontrolled ambient air. The researchers

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did not find any vascular response following the few hours of PM2.5 exposure, but noted declines in vascular response with elevated ambient particle exposures, possibly due to the deleterious contributions from mobile source emissions.

There are no long-term studies of human population exposure to ultrafine particles, as there is a lack of a monitoring network in the U.S. There have been several cross sectional epidemiological studies of ultrafine particles, mainly from Europe. Some of these studies found effects on hospital admissions, emergency department visits, for respiratory and cardiovascular effects. Other studies, however, have not found such effects (U.S. EPA, 2009). Concentrations of ultrafine particles can vary geographically, and it is not clear how well central site monitors may capture actual exposures.

The current U.S. EPA Integrated Science Assessment for Particulate Matter (U.S. EPA, 2009)[10] summarized that evidence is inadequate to determine a causal relationship between short-term exposures of UFPs to mortality or central nervous system effects, but that the evidence is suggestive of short-term exposures causing cardiovascular and respiratory effects. The Assessment also concluded that there is inadequate evidence linking long-term exposure of UFPs to health effects, including respiratory, developmental, cancer, and mortality. Overall, epidemiological studies of atmospheric PM suggest that cardiovascular effects are associated with smaller particles, but there are few reports that make a clear link between UFP exposures and increased mortality.

Recently, Hesterberg et al. (2011) hypothesized that the health effects caused by exposure to controlled diesel exhaust will be much less than those from uncontrolled diesel emissions, mostly because particles generated from nucleation of unfiltered sulfur vapors are believed to be less toxic than UFPs emitted from uncontrolled diesel combustion, which are made primarily of organic compounds (Seigneur, 2008). Additional studies are needed to support this hypothesis. The current ongoing Advanced Collaborative Emissions Study (ACES) will provide more data on the health effects of newer diesel engines meeting the U.S. 2007 standards. Similar testing may be necessary for advanced gasoline and alternative fueled engine exhaust as well as for the newer heavy-duty diesel engines meeting the U.S. 2010 standards.

[10] http://www.epa.gov/ncea/isa/pm.htm

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Considerably more information and data are needed in order to understand the underlying mechanisms and emission properties that affect human health. In 2011, the Health Effects Institute (HEI) convened an expert panel to conduct a critical evaluation of knowledge regarding the potential for UFP and NP to harm human health. The panel's report will be published as part of the HEI Perspective series. The Advanced Collaborative Emissions Study (ACES), which is jointly managed by HEI and the Coordinating Research Council (CRC) has undertaken a major effort to document improvements in vehicle emissions associated with advanced emissions controls. HEI investigators are analyzing the associated health effects.

Near-Roadway Health Impacts

Recent studies have found a positive association between living near busy roadways and asthma exacerbation, decreased lung function, increased heart disease, and other respiratory and cardiovascular effects (Kan et al., 2008; Andersen et al., 2010; HEI, 2010). Exposure to traffic emissions has also been linked to a faster progression of atherosclerosis in subjects living within 100 m of highways in Los Angeles (Künzli et al., 2010), increased risk of low birth weight and premature delivery (Llop et al., 2010; Wilhelm et al., 2011), and lower immune function and increased risk of Type 2 diabetes in post-menopausal women (Krämer et al., 2010; Williams et al., 2011). These studies do not differentiate exactly which pollutant or pollutants may be responsible.

Children are among the most susceptible segment of the population affected by exposure to traffic related pollutants. Their immune, neurological, and respiratory systems are still under development, they typically spend a substantial amount of time playing outdoors, and they have higher breathing rates per body mass. Neighborhood exposure to traffic-related air pollution has been linked to increased medical visits and hospital admissions for childhood asthma, increased wheezing and bronchitis, and the development of new asthma cases (McConnell et al., 2006; 2010; Chang et al., 2010).

In 2005 the District sent an advisory to all school districts under its jurisdiction to bring attention to findings regarding the potential for adverse health effects resulting from exposures to traffic emissions, and to encourage school districts to consider exposure to vehicle emissions when selecting and evaluating sites for new facilities such as schools, playgrounds, and residences (http://www.aqmd.gov/prdas/aqguide/doc/School_Guidance.pdf). As mentioned early in this document, the concentration of vehicle related pollutants drops off to near-background levels after about 300 m from the edge of the roadway (Zhu et al., 2002a;

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2002b). A survey of California schools revealed that approximately 2.3% of public schools were located within 150 meters of high-traffic roads (greater than 50,000 vehicles per day), and an additional 7.2 % were within 150 meters of medium traffic roads (25,000 – 50,000 vehicles per day) (Green et al., 2004).

FUTURE RESEARCH AND ASSESSMENT NEEDS

Chemical Composition

Large differences in UFP chemical composition depend on many factors, including vehicle technology, fuel used and after-treatment devices, but also on atmospheric chemical reactions after being emitted. Since particle composition may be a factor determining particle toxicity, there is a need for developing a better knowledge of UFP chemistry near roadways and in different environments.

Processes Leading to Formation

More work is needed to better characterize the mechanisms that lead to UFP formation right after emission and in the atmosphere. Developing a clearer picture of particle formation dynamics in different environments, including those which are influenced by traffic, would greatly assist control measures to regulate emissions of UFPs.

Standardized Measurement Methods and Procedures

Currently, there is no standard method for conducting size-classified or particle-number measurements. The terms UFP and NP are not clearly defined and often used improperly. In addition, the UFP characteristics measured in ambient and emission testing studies (e.g. volatile vs. solid components; mass vs. number concentration) are highly dependent on the measurement instrument/protocol used and its setting. Therefore, there is a need to develop and utilize standardized measurement methods and procedures to enhance meaningful comparison between results from different studies and to guarantee reproducible results.

Increased Measurements at "Hot Spot" Locations

The range of UFP number concentrations between clean and vehicle-affected environments spans over two orders of magnitude. UFPs and NPs are usually not uniformly dispersed in the atmosphere, but concentrated in areas where large numbers of vehicles are operated. Thus, future ambient UFP measurements should be

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conducted in areas where concentrations are likely to be higher ("hot spots"). These may include busy roads and intersections, rail yards, airports, etc.

Emission Inventories

Currently vehicle emission factors for different particle size ranges and for particle numbers are highly uncertain, and there are no emission inventories for UFPs from motor vehicles. Also, long-term UFP concentration data in urban environments is scarce. This knowledge is critical for developing management and control strategies for UFP emissions. New estimations of UFP levels should not be derived solely based on vehicle emission factors (which mostly reflect emissions of primary combustion particles), but have to include predictions for UFP formation near the tailpipe and in the atmosphere.

Air Quality Modeling

Exposure assessment of UFPs will require the development of modeling tools to simulate formation and transport over a wide range of atmospheric conditions and emission scenarios. In particular, there is a need to better understand the atmospheric dispersion and transformation of UFP and UFP precursor emissions within the first few hundred meters of the roadway, a region often characterized by complex flow. This complex flow may also affect how pollutants enter multi-story buildings characteristic of higher density environments. Additional new near-roadway studies and laboratory measurements are also necessary to better validate these models.

Health Effects

New toxicological and epidemiological studies targeting exposure to controlled and uncontrolled emissions from gasoline and diesel vehicles are needed to better characterize the exposure-response relationships to UFPs and to help develop health guidelines and potential regulations. The health effects of inorganic (largely related to oil consumption ash constituents) UFP emissions from vehicles are only now starting to receive significant attention.

Other Types of Sources

UFPs are formed through many types of combustion processes. Motor vehicles powered by internal combustion engines are major sources, but stationary source combustion and other processes also contribute significantly to UFP emissions and formation. More work is needed to better understand the size, composition and health impact of these particles near airports, rail-yards, port areas, natural gas electric generators and other potential "hotspot" locations.

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PLANNING AND REGULATORY ISSUES

Jurisdiction over Near-Roadway Exposures

The jurisdictional authority for controlling exposure to mobile source pollutants in the near-roadway environment is generally split between 1) federal and state authority over vehicle tailpipe emissions standards; and 2) local government (e.g. cities, counties) authority over land use planning and zoning decisions. In broad terms, tailpipe emission standards affect the source of mobile source emissions, while land use planning affects the exposure to those pollutants. In particular:

- On-road emission standards: U.S. EPA and CARB set standards for the level of pollutants that are allowed from new on-road engines and the fuels used to power them. Chapter 3 and Appendix III details how the emission standards for on-road vehicles are projected to affect total vehicle emissions in future years. While tighter emission standards in the future are expected to lower overall emissions, the near-roadway environment is still expected to have higher concentrations of mobile source pollutants relative to areas further away, especially for ultrafine particles.

- Local land use planning and zoning: local governments maintain the authority to determine the types of land use that are allowed within their jurisdiction. For example, in city General Plans, each parcel of land within that city is given a land use designation (e.g. residential, industrial, etc.). Land use types that do not fall within the General Plan designation are not allowed, with limited exceptions.[11] Because the majority of the area within the District jurisdiction has been built out in the past century, many of the current land use patterns are based on historical land use decisions. These legacy decisions have resulted in a large number of residents living in close proximity to freeways. As an example, approximately 691,000 people in Los Angeles County live within 500 feet of a freeway.[12]

[11] For example, school districts generally have the authority to supersede local land use authority when determining where to site new schools.

[12] 2012 Regional Transportation Plan, SCAG. Environmental Justice Appendix, Table 40.

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Sustainable Communities Strategies

Pursuant to California Senate Bill 375 (SB 375) passed in 2008, CARB developed regional greenhouse gas reduction targets for passenger vehicle emissions in years 2020 and 2035. As required by SB 375, the Southern California Association of Governments (SCAG) used these regional targets[13] to develop a Sustainable Communities Strategy (SCS) integrating land use, housing, and transportation planning, all as a part of the adopted 2012 Regional Transportation Plan (RTP).

One of the key features of the RTP/SCS is the encouragement of Transit-Oriented Development (TOD) that promotes higher residential and employment densities in High Quality Transit Areas (HQTA)[14]. Among the many benefits of well designed TODs, one of their primary purposes under SB 375 is to reduce the total vehicle miles travelled (VMT) in the region by placing homes and jobs closer to public transportation. However, because much of the original and planned transit network lies in close proximity to existing freeways, many of the HQTA areas overlap with freeway proximate areas. For example, with implementation of the RTP/SCS, approximately 282,000 households in the SCAG region will be located both within a HQTA and within 500 feet of a freeway in the year 2035. Some TODs can therefore present a challenge by potentially reducing regional emissions while increasing the exposure of residents in those project areas to elevated pollutant concentrations found in the near-roadway environment.

Enhanced Environmental Analysis

The California Environmental Quality Act (CEQA) requires that all projects requiring discretionary action by a public agency must evaluate and identify the potential environmental impacts of that project, and implement all feasible methods to reduce, avoid, or eliminate any significant adverse impacts.[15] This analysis is reported in CEQA documents such as Negative Declarations or Environmental Impact Reports. Therefore, CEQA requires that a project proponent analyze how the project itself may impact its surrounding environment. For example, if a project includes a new apartment building located adjacent to a freeway, the project will result in new

[13] 8% reduction below 2005 levels on a per capita basis by 2020, and 13% reduction by 2035

[14] A HQTA is defined as the ½ mile corridor surrounding a fixed bus route with service intervals no longer than 15 minutes during peak commute hours, or the ½ mile area surrounding a rail transit station, ferry terminal served by bus or rail, or the intersection of two or more major bus routes with service intervals no longer than 15 minutes during peak commute periods. See Public Resources Code 21155(b) and 21064.3 for further details.

[15] Public Resources Code §21000 *et seq.*

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emissions from vehicles driven by future residents of the apartment building, and these emissions must be evaluated to determine the impact on air quality and the environment.

In a more rigorous CEQA analysis, the impacts from the surrounding environment on people living in the project itself could also be evaluated (Figure 9-5). Using the same example from above, emissions from all of the vehicles on the adjacent freeway would also be evaluated for their potential impact on the proposed apartment residents.

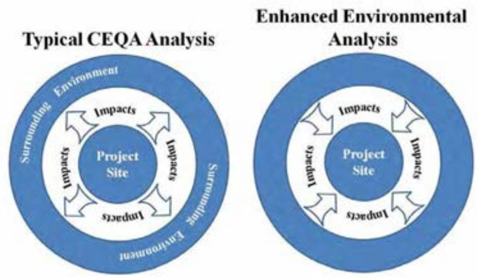

FIGURE 9-5

Example of Typical and Enhanced Environmental Analyses

Although section 15162.2 of the CEQA Guidelines provides that an environmental impact report "shall also analyze any significant environmental effects the project might cause by bringing development and people into the area affected," recent court rulings have found that CEQA does not require an analysis of the impacts of the environment on a project.[16]

[16] *Ballona Wetlands Land Trust v. City of Los Angeles* (2011) 201 Cal.App.4th 455, 473-474 (a revised environmental impact report for a coastal multi-family residential development was not *required* to address impacts on the project from sea-level rise caused by global warming); *see also South Orange County Wastewater Authority v. City of Dana Point* (2011) 196 Cal.App.4th 1604 (analysis of impacts from locating a residential development next to an existing source of noxious odors was not *required*)

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However, notwithstanding these court rulings, lead agencies (such as a city or county or air district) that approve CEQA documents retain the authority to include any additional information they deem relevant to assessing and mitigating the environmental impacts of a project. Because of the District's concern about the potential public health impacts of siting sensitive populations within close proximity of freeways, District staff will continue to recommend that, prior to approving the project, lead agencies consider the impacts of air pollutants on people who will live in a new project and provide mitigation where necessary.

Guidance is available for conducting health risk assessments related to mobile sources from the District and from the California Air Pollution Controls Officers Association (CAPCOA).[17]

Mitigation Measures

A variety of mitigation measures have been proposed and are under study to reduce exposure to the high concentration of pollutants found in the near-roadway environment. Although some of these exposure controls may have some effectiveness, the solution that would have the greatest effect still lies in source control. Reducing vehicle emissions remains the only way to ensure that all pollutant concentrations in the near-roadway environment can be reduced for everyone, not just for certain pollutants, or for those that can implement mitigation. While emissions from vehicles are expected to continue to decline with existing regulations and fleet turnover, near-roadway environments are still expected to have elevated concentrations of some mobile source pollutants for the foreseeable future. In the interim, there are some measures that may reduce exposure that are briefly described in the table below. All of these conventional methods require further research to determine their effectiveness and feasibility for the variety of land uses found in the near-roadway environment. In addition, District staff will continue to support and monitor the outcome of research on newer technologies such as photocatalytic cement, roadway canopies, and sound barriers with active or passive filtration/ventilation.

Besides buffer zones, none of the measures listed in the table below (Table 9-1) has been found to be effective to reduce all mobile source pollutants to background levels in the near roadway-environment. Because of this limitation, the mitigation

[17] http://www.aqmd.gov/ceqa/handbook/mobile_toxic/mobile_toxic.html
http://www.capcoa.org/wp-content/uploads/2012/03/CAPCOA_HRA_LU_Guidelines_8-6-09.pdf

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considered for new land uses may be different than that considered for existing land uses. For example, new land uses could consider buffer zones or site configurations before considering other measures such as enhanced HVAC filtration.

For existing land uses that do not have the same ability to incorporate buffer zones as new land uses, other measures may be considered first, such as encouraging development of outdoor recreation spaces and playgrounds within walking distance but beyond 300 m from a freeway at the same time as considering enhanced filtration in HVAC systems.

Emission Control Technologies

The application of advanced emissions control technologies to both compression-ignition (diesel) and spark-ignition (gasoline, natural gas) engines has led to new concerns about the formation and health effects of UFPs. Since larger accumulation mode particles have effectively been removed from the exhaust of state-of-the-art vehicles, this has eliminated possible condensation surfaces for volatile gases and UFPs. The net result is that while larger-sized particles (accounting for most of the PM mass) are dramatically reduced by control technologies such as diesel particulate filters (DPFs), an increase in the number of UFPs and NP may potentially occur. Additional evaluation regarding a possible increase in UFP and NP number concentration should be addressed. Below is a brief description of the two main PM control technologies in use today:

- Particulate filters are devices capable of achieving over 90% reduction of the solid portion of the total exhaust particles, with some control of the soluble organic fraction (SOF). With most of the solid particles removed, nucleation, rather than condensation, of the remaining gas phase species can occur, potentially increasing particle number emissions (Morawska et al., 2008). However, particulate filters can also be effective in controlling UFPs if designed properly, for example when used in conjunction with an oxidation catalyst.

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TABLE 9-1

MITIGATION MEASURE	POLLUTANT TARGETED	RANGE OF REDUCTION	COMMENTS	KEY REFERENCES
Buffer zones	All pollutants	0-100%	Varies with distance. Up to 100% reduction to background levels at 500 feet.	-CARB Air Quality and Land Use Handbook, (2005) (http://www.arb.ca.gov/ch/handbook.pdf)
Enhanced filtration in building Heating, Ventilation, and Air Conditioning (HVAC) systems	PM	30-90% for indoor environments	Effectiveness varies depending upon rating of filter (>MERV 13 recommended near roadways), HVAC design, maintenance of HVAC system, whether doors and windows stay closed, and amount of time people spend outdoors	-AQMD Pilot Study of High Performance Air Filtration for Classroom Applications (http://www.aqmd.gov/rfp/attachments/2010/AQMDPilotStudyFinalReport.pdf) -SCAG 2012 RTP/SCS PEIR Appendix G Measure AQ-19 (http://rtpscs.scag.ca.gov/Documents/peir/2012/final/2012fPEIR_AppendixG_ExampleMeasures.pdf)
Sound walls	All pollutants	15-50% close to barrier at ground level	Effectiveness varies with distance from freeway, with concentrations sometimes increasing >80m downwind of wall. Other site-specific characteristics may significantly alter effectiveness.	-Impact of noise barriers on near-road air quality, Baldauf et al., (2008) -Impact of noise barriers on particle size distributions and pollutant concentrations near freeways, Ning et al., (2010) -The effect of roadside structures on the transport and dispersion of ultrafine particles from highways, Bowker et al., (2007)
Vegetated barriers	PM	Varies	Effectiveness varies with barrier height, thickness, density, and species. Some configurations may increase concentrations.	-Local measures for PM10 hotspots in London, Air Quality Consultants (2009) -Field investigation of roadside vegetative and structural barrier impact on near-road ultrafine particle concentrations under a variety of wind conditions, Hagler et al., (2012)

Common Mitigation Measures Adopted To Reduce Exposure to Motor Vehicle Emissions In Near-Road Environments

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- Oxidation catalysts are effective in removing more than 90% of the SOF fraction of total emissions as well as UFPs formed later in the exhaust. Their effectiveness, however, depends on whether the catalyst is formulated to produce little or no sulfate emissions at high temperature. In fact, special catalyst formulations must be employed to hinder the catalytic generation of sulfate particles from SO2 present in the exhaust gas. While oxidation catalysts are effective in reducing the SOF fraction and smaller particles, it has little effect on larger accumulation or coarse mode particles. An effective control technology should be based on a system addressing both particle mass and number emission reduction.

Testing Protocols

Under the U.S. gravimetric method for certifying heavy-duty engines, exhaust PM mass is collected on inert filters as each engine is operated over official engine dynamometer testing schedules (e.g. the Federal Test Procedure, or FTP). A constant volume sampler (CVS) system collects the exhaust at prescribed conditions (e.g. temperature, dilution ratio). The preconditioned particulate filters are then weighed to obtain the mass of PM emitted over the test cycle. The mass of emitted PM is then normalized according to the work performed over the test cycle in brake horsepower-hour (bhp-hr). The calculated mass emissions values are compared to the PM emissions standard in g/bhp-hr.

Procedures for characterizing emissions from light-duty (diesel) vehicles are similar from the perspective of collecting the PM on preconditioned filters and determining mass emissions. A key difference is that the light-duty vehicle emissions standards are in grams of pollutant per distance driven (g/mile in the U.S.), instead of work performed. Testing of light-duty vehicles is conducted on chassis dynamometers in contrast to heavy-duty engines, which are tested on engine dynamometers prior to vehicle integration.

In the U.S., the focus on measuring and controlling PM emissions has been almost exclusively on the heavy-duty vehicle sector, because overall emissions are dominated by diesel engines. The mass-focused testing methodology described above has worked well for heavy-duty engine technologies meeting PM standards of 0.1 g/bhp-hr (i.e. up to the 2006 engine model year). Such engines emit relatively large amounts of solid material (soot, metals, and ash) from combustion, engine wear, and lube oils. All of this is collected on the preconditioned filters, along with volatiles in the exhaust that condense on the filters including water vapor, sulfates, and other

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organics. The net result is that the mass of PM collected during the test cycle over a known amount of work performed can be compared to the PM emissions standard.

However, as more advanced diesel PM control technology was developed and deployed to meet tighter emissions standards (DPFs to meet the U.S. 2007 heavy-duty engine PM standard) the PM mass collected over the FTP was significantly reduced. In some cases, PM mass levels were too low for detection by existing instrumentation in the test methodology. Also, at these low mass levels, testing anomalies can occur due to absorption of semi-volatile gas molecules on sampling filters or on PM already collected, which possibly leads to bias towards higher weight measurements. Similarly, tunnel wall or sampling line losses can also cause erroneous results. The need for better precision at low mass levels led U.S. EPA to revise the protocol to improve accuracy. At the same time, testing in the United States and in Europe shed new light on the characteristics of diesel PM in the exhaust, raising questions as to the relative importance of measuring particle mass versus particle number and/or size (Swanson et al., 2010).

In the late 1990s, the occupational health and safety authorities of Austria, Switzerland and Germany conducted a comprehensive program called Verminderung der Emissionen von Real-Dieselmotoren im Tunnelbau (VERT), which in English stands for Reduction of Diesel-emissions in tunneling to ensure functional and beneficial systems are utilized for the removal of harmful diesel emissions in underground environments. One of the main objectives of VERT was to look at the composition of diesel exhaust in terms of particle size, surface area, and concentration, and to establish whether mass is a good proxy for subsequent exposures and human health effects. PM, primarily BC and UFPs were found to be of major concern to the extent that in tunneling and other major construction sites, particle-traps for diesel equipment/vehicles became mandatory. This work laid the foundation for two additional important programs, the "Particulates Program" and the "Particle Measurement Programme" (PMP), both of which are further discussed below.

- Particulates Program: this program developed a sampling procedure to characterize both the volatile and non-volatile components of exhaust emissions from light- and heavy-duty vehicles. In particular, it developed sampling methodologies capable of assessing the formation of nucleation- and accumulation-mode particles from a minimum size of 7 nm. Figure 9-6 shows the sampling system used in the Particulates Program. The main results for light-duty

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and for heavy-duty-vehicle applications are described in Ntziachristos et al. 2004, and in Thompson et al. 2004, respectively.

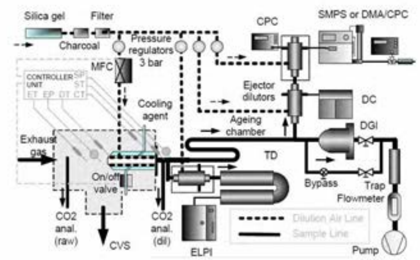

Figure 9-6

Sampling System used in the Particulates Program (from Samaras et al., 2006)

The basic premise behind the testing protocol was that each vehicle technology can and should be tested under consistent conditions. This enables comparison between the various technologies and fuels used. The procedure entails measuring particle mass, active surface (surrogate for surface area), solid particle number, total particle number, and particle size distribution. Both light-duty and heavy-duty programs investigated the effects of vehicle technology, fuel properties, and driving cycle.

- Particle Measurement Programme (PMP): this program is aimed at developing a test protocol to measure only the impact of solid particles in motor vehicle exhaust. The PMP is a collaboration of the United Nations Economic Commission for Europe and GRPE (Working Party on Pollution and Energy). The goal of this program is to find a new approach to measure particle emissions from vehicles that can either replace or coexist with the current mass-based particulate measurements. A result of this work has been the development of instrumentation and methodologies for counting solid (i.e. low-volatility particles that survived evaporation after a residence time of 0.2 seconds at 300 ^{0}C) particles down to a size of 23 nm. The PMP was implemented in a number of testing labs in Europe, Japan, and the U.S. The results of the lab emission testing for light- and heavy-duty vehicles is provided by Andersson et al. (2007; 2010). Figure 9-7 shows an example of a PMP setup for particle number count testing. New test requirements

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are continuously being added to European light-duty vehicle emissions regulations, including those specific to particle number.

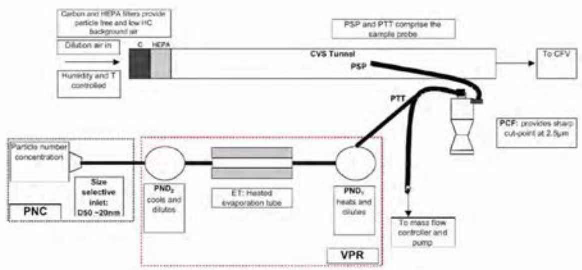

FIGURE 9-7

Schematic of PMP Testing Setup for Particle Number Count (from Kasper et al., 2006)

There have also been a number of related studies or research reports on the evaluation of various components of the PMP methodology. For example, CARB studied this method for light-duty vehicles using the "Golden Vehicle" (GV; a single vehicle that has been shipped to laboratories in Italy, Sweden, United Kingdom, Germany, Greece, Japan, Korea and France for testing) and the Golden Particle Measurement System (GPMS; a set of particle counting instruments that was sent along with the GV) to compare results with the other nine international laboratories that participated in the PMP (CARB, 2008).[18] Additional testing was done on heavy-duty vehicles and results indicated that further study was needed to include a wider range of vehicles and after-treatment systems (Robertson et al., 2007).

The PMP protocol has gained acceptance in Europe and Japan. American regulators, industry and researchers continue to evaluate this methodology. Researchers in the U.S. (e.g., Swanson et al. 2010) favor alternative methods that focus on measuring surface area including solids and volatiles. Kittelson et al. (2011) noted that for engines equipped with particle filters setting the limit to 23 nm effectively regulates all sizes. However, vehicles without filters may emit large concentrations of solid

[18] http://www.arb.ca.gov/research/veh-emissions/pmp-ld/CARB_Golden_Vehicle_PMP_Report_Final-05JAN09.pdf

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particles below 23 nm that are not counted by the current method. The next generation of high-efficiency direct injection gasoline engines is also challenged by the current 23 nm limit. They proposed extending solid PM measurements to 10 nm although this may be problematic due to formation of particles as small as 3 nm downstream of the PMP Volatile Particle Remover (VPR) system.[19]

As noted, the European PMP protocol has been implemented to include numbers-based particle emission standards. While there is no consensus in the U.S. at present regarding how to standardize particle measurements, research work and regulatory discussions are ongoing among industry and regulatory agencies such as U.S. EPA, CARB, and the District. For now, U.S. EPA and CARB continue to regulate PM mass only.

Emissions Standards

European Standards

Europe's new emission levels for light-duty and medium-duty vehicles are Euro 5 and Euro 6. Euro 5's goal is to reduce the emissions of PM from diesel cars from 25 mg/km to 5 mg/km. Euro 6 will become effective in January 2014, and will reduce the NO_x emissions from diesel cars from 180 mg/km to 80 mg/km. A solid particle number emission limit of $6x10^{11}$ km^{-1} became effective in September 2011 for all categories of diesel vehicles. Europe's reason for adopting the number standard is to promote the use of DPF technology. A particle number emissions limit for gasoline vehicles will be determined in 2014.

California Standards

In 2010, CARB considered adopting certain particle number standards as an alternative under the LEV III requirements, and proposed that for all vehicles subject to LEV III, beginning in 2014, manufacturers must select one of two standards to demonstrate compliance (CARB, 2010)[20]:

1. Federal Test Procedure weighted PM mass emission limit to 0.006 g/mi (2014) and 0.003 g/mi (2017)

2. Federal Test Procedure weighted particle number emission limit to $6.0x10^{12}$ particles/mi (2014) and $3.0x10^{12}$ particles/mi (2017)

[19] http://www.unece.org/fileadmin/DAM/trans/doc/2011/wp29grpe/PMP-26-06e.pdf
[20] http://www.arb.ca.gov/msprog/levprog/leviii/meetings/051810/pm_disc_paper-v6.pdf

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CARB's reason for proposing the particle number limit is to take advantage of the latest methodology advances by PMP. The PMP method was considered because it is the only particle emission measurement method that went through extensive international scrutiny and laboratory testing. Excellent sources of information about CARB's LEV III proposals and objectives specific to fine particles can be found on CARB's 2011 publication "LEV III PM Technical Support Document: Development of Particulate Mass Standards for Future Light-Duty Vehicles".[21]

National Standards

The National Ambient Air Quality Standards (NAAQS) set by the U.S. EPA are designed to protect public health and the environment. The standards are developed based on a variety of scientific studies, including the results of epidemiologic studies that evaluate how human health has been affected by pollutant concentrations in the past. These standards are periodically reviewed and updated based on recent scientific developments. Most recently, the NO_2 and CO NAAQS were reviewed and updated, with a new provision that new permanent monitors must be established near roadways. The most recent AQMD monitoring plan provides details about how and where these new monitors may be located.[22] The recent PM NAAQS revision proposed on June 14, 2012, by U.S. EPA for the first time includes near-roadway monitoring requirements for PM2.5. Currently, U.S. EPA notes that, in their assessment, there is not sufficient health evidence to support a separate standard for UFPs.

DISTRICT FUTURE ACTIONS

Although the District has limited authority to regulate mobile source pollution in the near-roadway environment, there are a variety of measures that District staff will continue to take to reduce this public health impact.

- The District will continue to fund health effects, exposure, atmospheric chemistry, modeling, and other research activities aimed at investigating the impact of UFPs exposure in communities impacted by traffic emissions. An AQMD-funded study is currently underway to assess potential air quality impacts and the effectiveness of mitigation measures (e.g. sound walls and vegetated barriers) in the near roadway environment. The multi-pronged approach of this study includes a

[21] http://www.arb.ca.gov/regact/2012/leviiighg2012/levappp.pdf
[22] http://www.aqmd.gov/tao/AQ-Reports/AQMonitoringNetworkPlan/AQnetworkplan.htm

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review of different mitigation techniques implemented throughout the world, pollutant monitoring combined with dispersion modeling of local freeway emissions, development of alternative models, and laboratory-based simulations in flow tanks. The results of this study are expected by early 2013.

- Since the problem of near-roadway exposure can effectively be addressed by controlling tailpipe emissions, the District will continue to encourage U.S.EPA and CARB to set vehicle emission standards for UFP.
- District staff will continue to work with local and state agencies to address near-roadway exposures. This includes outreach and education to local governments and elected officials on the health risks associated with mobile source pollution and recommending measures that can be taken to reduce those risks. As an example, General Plans prepared for a city can include requirements to provide buffer zones, as feasible, between freeways and any new development with sensitive receptors.
- Through the CEQA Intergovernmental Review program, CEQA documents submitted to the District are reviewed during the public comment period. For those projects that may expose sensitive populations to elevated concentrations of mobile source pollution, District staff will recommend that the potential impacts be quantified and that all feasible mitigation measures be considered to reduce this impact below a significant level.
- As part of the Clean Communities Program (CCP), District staff will continue to work in the pilot study areas of Boyle Heights and San Bernardino to address exposure to mobile source pollution and will apply those lessons learned to other areas in the District. Further, as part of CCP Measures Outreach-1 and Agency-01, District staff will prepare a document titled "Proximity Matters" that will provide an additional resource for local agency planners to use when addressing near-roadway exposures.
- On July 1, 2012 the District began MATES IV, a year-long study designed to characterize the carcinogenic risk caused by exposure to air toxics in the Basin. MATES IV will enhance the spatial resolution of previous measurement efforts by characterizing the localized exposure to UFPs and Diesel Particulate Matter in residential, industrial, and commercial communities. Mobile monitoring platforms will be deployed for short-term monitoring at six to eight sites in areas close to mobile sources such as airports, rail yards, freeways and warehouse operations.

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- District staff will continue to work with instrument manufacturers, CARB, and U.S. EPA on the evaluation of new technologies for monitoring UFPs, BC and other traffic-related pollutants, and on the development of methods for the standardization of UFP measurements.

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Exhibit F

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32.14.2H
32.14.2C

Review of the "Legacy Avian Noise Research Program: Final Report"

Submitted to: The Nature Conservancy of Utah
Submitted by: John F. Cavitt, Ph.D.

7/1/2013

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WEST DAVIS CORRIDOR

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Review of the "Legacy Avian Noise Research Program: Final Report"

This document provides a detailed review of the "Legacy Avian Noise Research Program: Final Report" (Biowest 2011; hereafter referred to as LANRP). The review evaluates and provides comments on the LANRP design, implementation, analysis and conclusions (Section 1). In addition, the review also addresses key questions related to the LANRP and the proposed West Davis Corridor (Section 2).

Section 1. LANRP Review

The LANRP is a technical report authored by Bio-West, Inc., an environmental consulting firm operating in several western states including Utah. The LANRP documents the results of a 4-year study to assess the impacts of highway noise on breeding bird communities within the Great Salt Lake (GSL) Ecosystem. Bio-West designed and implemented the study under contract with the Utah Department of Transportation. The LANRP was required as a portion of the mitigation for construction of the Legacy Parkway (UT State Route 67), an 18.5 km, four-lane freeway located in Davis County, Utah.

The study objectives for the LANRP were to assess the potential impacts of highway noise on avian diversity, richness, density and productivity. In order to examine these objectives, the authors established study sites located at varying distances to paved highways (min distance range 0.05 – 23.86 km). A total of six sites were utilized in 2007, seven in 2008 and nine in 2010. Avian diversity, richness and density were determined with a "variable-radius" point count method. Points were distributed within four habitat types – emergent marsh, grassland, playa and wet meadow. Productivity was measured by locating and monitoring nests of two common, semi-colonial shorebirds, American Avocet (*Recurvirostra americana* ; AMAV) and Black-necked Stilt (*Himantopus mexicanus*; BNST) and a small, solitary-nesting shorebird, the Snowy Plover (*Charadrius nivosus*; SNPL). Noise levels at each point-count station and nest were measured in decibels (dB) with sound level meters.

The review of the LANRP is divided into four sub-sections. The first, "Study Design and Implementation", provides comments on the design of the project, as well as methodologies used in the collection of data. The second subsection, "Analysis", includes detailed comments on the statistical techniques used to test hypotheses of the data set. The next component, "Study Conclusions and Limitations", provides comments on the interpretation of the LANRP results provided by the authors and the extent to which the study addressed the stated objectives. Finally, "Minor Comments" are included at the end of the review.

A. Study Design and Implementation

1. The LANRP is an observational study, testing for the effects of highway noise on avian breeding populations. By their very nature, observational studies are limited because investigators have no influence over which subjects (e.g. study areas) receive which "treatments" (e.g. distance to nearest highway). Consequently, observational studies can only identify associations between

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variables and are unable to establish cause and effect (i.e. experimental studies; Whitlock and Schluter 2009). However, when properly designed, an observational study should include all of the features of a good experiment that are used to minimize bias and the impact of sampling error, with the exception of randomization. In an observational study such as the LANRP, the researcher is unable to assign "treatments" (i.e. distance to highway) to subjects (i.e. study sites). Consequently, the greatest challenge in designing an observational study is to minimize bias resulting from confounding variables within the study sites (Whitlock and Schluter 2009). A confounding variable is an extraneous factor, not controlled by the researcher, whose presence affects the key variables being studied so that the results do not reflect the actual relationship between the variables under investigation (Whitlock and Scluter 2009).

Two basic strategies are commonly used to limit the effects of confounding variables. The first technique is called *matching* (e.g. Kupper et al 1981), where sites are paired with a control (or in the case of the LANRP, a distant highway site) having the same or closely similar values for the suspected confounding variables (Kupper et al. 1981, Whitlock and Schluter 2009). The second technique is referred to as *adjustment*, whereby statistical techniques (e.g. Analysis of Co-variance, Sokal and Rohlf 1981) are used to correct for differences between sites.

For studies such as the LANRP, the selection of study sites is critical for providing reliable information free from sampling error (Bibby et al. 2000). Unfortunately, it appears that very little attention was given to this portion of the study design. The authors did not use *matching* or *adjustment* to limit the effects of confounding variables. This greatly reduces the value of the study and the conclusions drawn from it. The following list provides important confounding variables that should have been addressed in the study design phase or during statistical analysis.

- Habitat differences. The study sites selected for the LANRP differ significantly in the type of habitat provided for breeding aquatic birds. These habitat differences are not evenly spread across the sites utilized or in relation to the distance sites are from highways (see Table 1 below). The authors selected six study sites < 1 km from the nearest highway, 2 sites 2 – 5 km and 1 site > 23 km from the nearest highway (see Table 1 below and *LANRP Table 1, 2 pg. 5*). However, the site located furthest from any highway, Locomotive Springs Waterfowl Management Area (LSWMA), contained no data from either the grassland or playa habitat types. Furthermore the two intermediate distance sites, Great Salt Lake Shorelands Preserve (GSLSP) and Salt Creek Waterfowl Management Area (SCWMA), only had 6% and 7% respectively, of points distributed within the playa habitat types. To further complicate the study design, many of the sites within 1 km of highways oversampled playa with roughly 32% of all points located within this habitat type (Table 1). Unfortunately, the authors do not account for this in any of the analyses nor do they even address this potential confounding variable. Because avian communities differ within these habitat types at GSL (Paul and Manning 2008), it is likely that any differences observed (or not observed) could be solely the result of habitat differences across study sites.

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- Site management. The authors indicate that study sites were selected because they were highly managed with regard to water levels. Yet, even the Waterfowl Management Areas (WMAs) receive different amounts of water and manage those allocations differently (J. Dolling, R. Hansen pers. comm.). In addition, the authors included sites with far less active water management such as GSLSP and Legacy Nature Preserve (LNP). For wetland nesting birds, the amount, timing and duration of water within the various habitat types dictates their composition, abundance, and success (Kadlec and Smith 1989, Colwell 2010). The authors do not address this difference in water management nor do they indicate how water levels and precipitation fluctuated during the study. Both the total precipitation received, and GSL water elevations differed significantly throughout the LANRP study. Total annual precipitation measured at the Salt Lake City International Airport varied over 17.8 cm during the four-year study (Western Regional Climate Center 2013) and GSL water elevation decreased from 4196.3' in 2007 to 4194.7' in 2010 (USGS 2013). Consequently, it is very likely that these differences in water management and variation in precipitation/GSL elevations affected the avian communities. However, no discussion of this potential impact is made nor any attempt to measure its effect on the variables studied. A second confounding factor associated with variation in study site management, is the extent to which predators are removed during the breeding season. Predator control is an important management technique that has been shown to increase nesting productivity as well as population sizes of breeding birds (Newton 1998). Farmington Bay Waterfowl Management Area (FBWMA) has a very active predator control program, whereas the Inland Sea Shorebird Reserve (ISSR) does not. The extent to which predator management occurs within all sites should be considered as it can have important consequences not only for interpreting the results from the productivity portion of the LANRP but also the analyses of avian richness, diversity and abundance. Given the important differences in site management, the LANRP should have in the very least discussed these confounding factors and tested for any potential effects.
- Study site area. The concept of species-area relationships is perhaps one of the most well-documented ecological principles in conservation biology (Soulé and Wilcox 1980, Rosenzweig 1996). The species-area relationship (or curve) is the concept that as one samples from larger habitats more and more species are detected. The relative numbers of species also seem to follow predictable mathematical relationships (Rosenzweig 1996). Although the information is not provided in the LANRP, a quick search indicates that the sites used in the study differ significantly in area (Table 2). For example, Timpie Springs WMA (TSWMA) is 12 times smaller than FBWMA. Differences in diversity, richness, and density between large wetland complexes and very small sites could be due solely to species-area relationships. Species-area relationships are not considered or mentioned as a potential confounding factor.

Each of these confounding factors suggests that the selection of study sites in the LANRP is not free from sampling error. The nature of observational studies makes the elimination of confounding variables

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difficult, however the authors did not attempt to reduce the effects of the most important factors nor test for their potential impacts throughout the design and analysis phases.

2. Throughout the LANRP, the authors do acknowledge that their experimental design is unable to account for the confounding effects of non-highway noise (agriculture, industry etc). They do indicate that a negative relationship was observed between distance to the nearest highway and mean noise level. However, the authors do not provide any results for this analysis so that the reader can understand the magnitude of this relationship nor do they provide the amount of variation in noise levels that are explained by proximity to highways (P-values, R^2, df etc.). Without this information it is impossible to understand the impact that non-highway noise may have on the results.
3. One of the most significant sources of bias in surveys of avian communities is the individual observer (e.g. Bibby et al. 2000, Gregory et al. 2004). People differ significantly in their birding skills, survey experience and attention to detail. Consequently, bias can be incorporated into survey results if observer effects are not minimized or adjusted within analyses. Surveys, such as the LANRP, that are conducted three times a year, across nine different sites, and over four different years would be difficult to organize with a single observer. It is thus likely that multiple observers participated in the surveys. However, the LANRP does not provide any information on the number of observers, level of their experience in avian surveys or training they were provided. In the very least the study authors should have addressed this potential source of bias and preferably tested for an observer effect in the data. Without this information it is unclear if any bias is included in this study through variation in observer skill or ability.
4. The authors indicate that individual birds detected by calls or songs were not used in the analyses of species-specific density estimates and noise effects. This is justified for a study such as this examining the impacts of noise on avian populations. One would assume that in sites with greater noise a reduction in species detections would occur, if songs and calls were used. However, the authors did not indicate that this same process was used in the analysis of species richness and diversity. Furthermore, the authors need to explain how the exclusion of data was implemented and what species and proportions of observations were not included in the analyses. It appears from both the text and the data that field observers did record birds detected by both visual and auditory cues. In the analysis section, the authors state "Only visual detections were used to eliminate highway or other noise confounding auditory detections of birds" (*LANRP – Species-Specific Density Estimates, pg. 10*). Furthermore, data provided in Table 4 of the LANRP (*pg. 21*) include several species that, because of their behavior and/or preference for dense habitat, are very difficult to detect without the aid of their songs or calls (e.g. Marsh Wren, Common Yellowthroat, Savannah Sparrow, Sora, Virginia Rail, Brewer's Sparrow, Grasshopper Sparrow, Yellow Warbler). If field observers were using both aural and visual cues to locate and count birds then this could potentially lead to additional bias in the data. No information is provided that ensures the authors were able to distinguish in the data-set between birds only detected via visual cues versus those first detected via vocalizations and then visually located. It is quite possible that observers, unless provided detailed information

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and training, may inadvertently use vocalizations to orient their attention to areas of activity where then, visual identification could be made.

5. The authors utilized a point-count method for comparing the diversity, richness and abundance of wetland birds. They justified the choice of this method because it can provide a robust estimate of breeding bird densities and that "it would be difficult to position line-transect routes within a dominant vegetation community" (*LANRP pg. 3*). However, for a study such as the LANRP, point-counts are likely not suitable for detecting birds. Point counts rely on the observer remaining stationary, detecting birds by both sight and sound (Ralph et al. 1995). Consequently, if only visual observations were analyzed, as reported by LANRP authors, the observer is likely missing individuals and species that are cryptic and secretive (see also A4 above). For this reason, a line transect would be preferred. In this method, the observer walks standardized routes within the study sites and records birds detected along the route. The movement of the observer is important by allowing the detection of birds flushed by the observer that might not otherwise be noticed. Transects are also generally more efficient and accurate than point counts. Given the movement of the observer along the route, transects allow for recording more individuals per unit time (Bibby et al. 2000). They tend also to be more accurate because the impact of bias only rises linearly for line transects but geometrically for point counts (Bibby et al. 2000, Gregory et al. 2010). In addition, double counting is less of a concern for line transects (Gregory et al. 2010). Because transect routes can be either randomly allocated or stratified by habitat type, they are very adaptable to studies of wetland birds. This technique was successfully used to survey SNPL throughout its breeding range including GSL (Thomas et al. 2012), used to monitor and assess the avian population utilizing the LNP (E. McCulley pers. comm) and was the basic technique used for much of the GSL Waterbird Survey (Paul and Manning 2008).
6. Species richness, diversity and abundance was assessed in the LANRP by conducting three surveys per year (May – late July and early Aug) at each site. The authors provide no indication of how these surveys were collected or randomized between sites. In addition, they provide no indication of when each survey was collected other than at least 2-3 weeks apart. This information suggests that some sites had successive visits every 2-3 weeks and perhaps other sites had surveys separated by longer intervals. GSL and associated wetlands experience extremely large temporal changes in abundance and species richness (Paul and Manning 2008), so the methods used for the randomization of site visits and the timing of surveys is critical to avoid introducing bias and/or sampling error into the data.
7. The LANRP provides nest productivity data collected from sites located at varying distances to highways. The authors provide very little insight into the selection of the species used (AMAV, BNST and SNPL) other than they are common nesting birds found in GSL wetlands. The authors also fail to indicate what the study objectives are for examining nesting productivity and how noise may influence nesting success? If the authors are suggesting highway noise may mask predator movements, then they are assuming that 1) adult nesting birds detect approaching predators via aural cues and 2) that they can then dissuade the predator from taking the nest contents after detection. These assumptions may not be valid for the species chosen in the LANRP. Avian predators (e.g. gulls and ravens), for these breeding species are most likely

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detected by visual rather than through aural cues. Mammalian predators (raccoon, skunk, coyote, fox) of AMAV, BNST, and SNPL at GSL are nocturnal (Cavitt et al. 2008) and more likely to be detected via auditory cues. However, several studies have suggested that nesting birds engage in very little nest defense behavior at night (Bradley and Marzloff 2003, Ellison and Ribic 2012), so the ability to reduce the chance of nest predation via nest defense with nocturnal predators is likely small for this suite of breeding birds. Furthermore AMAV and BNST are semi-colonial nesting species and they preferentially select open areas with very sparse vegetation in order to visually detect approaching predators. In this environment, it is far more likely that visual detection of predators is much more important than aural cues. Data from the LANRP study and others suggest nesting success for these species is influenced primarily by nest site selection and colony size. Solitary nesting species that nest in upland or grassland sites may be more sensitive to noise masking predator movements than the species selected for the LANRP.

8. A portion of the productivity study attempted to test the association between noise levels and nesting success. However, due to the study design and species utilized, the authors were only able to measure noise levels after nest termination. The authors do not indicate how long after nest termination this occurred or at what time of day. The reader is left to assume that measurements took place in association with point counts. No information was presented to suggest that noise levels were similar while nests were active versus when the measurements were actually recorded. In addition, since nocturnal predators are important within this ecosystem (see A7 above), noise levels should have been recorded at night for this analysis. It is reasonable to suspect that highway noise exhibits a significant temporal pattern.
9. Within the productivity data presented, the LANRP reports an exceptionally high percentage of nests with an unknown fate (20.9%). This is not typical of nesting studies in general (Martin and Geupel 1993) or of these species in particular (Cavitt 2006, Cavitt et al. 2008). In addition, the percentage of nests with unknown fates appears to vary significantly among sites (*LANRP Table 8, pg. 25*). Some sites had relatively moderate levels of unknown nesting fates however, the GSLSP had over 40% of AMAV and BNST nests classified as unknown. This makes any interpretation of data on nesting success highly speculative. With over 20% of all nests that were monitored for this study not assigned a nesting fate (i.e. failed or successful), it is not possible to make inferences from the data and calls into question all the results of the nesting success analyses. This high percentage of unknowns is likely the result of infrequent nest visits (Martin and Geupel 1993).
10. The GSL and its associated wetlands serve a critical function as staging and wintering areas for millions of aquatic birds during their annual migrations (Paul and Manning 2008). In fact, far more birds utilize these habitats during migration than for breeding (Paul and Manning 2008). The LANRP only provides information on the effects of noise on avian breeding populations and does not account for the importance of GSL at these other portions of the annual cycle. Noise and disturbance are likely to be more important for shorebirds during migration than during breeding (Colwell 2010). Shorebirds have a higher metabolic rate relative to other similar-sized birds (Kersten and Piersma 1987). As a consequence, they require undisturbed foraging opportunities in order to build reserves for long-distance migrations. Human-induced disturbance, such as noise may adversely impact the ability of migratory species to gain

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sufficient body reserves by reducing their daily energy intake (Colwell 2010). Consequently, the most sensitive time for aquatic birds using GSL may have been overlooked by the LANRP.

B. Analysis

1. All of the statistical techniques used in the LANRP analysis, assume that data are a random sample from the population, in which each individual has an equal and independent chance of being sampled (Sokal and Rohlf 1981). Unfortunately the design and analysis of many portions of this study were conducted in such a way that violates this assumption of independence. Pseudoreplication occurs in a study whenever individual measurements are not independent but are analyzed as if they are independent of one another (Hurlbert 1984). "Replication" in a statistical analysis is important and refers to the sampling of multiple independent units from a population. Replication enables one to estimate population characteristics and the precision of those estimates. In general, the greater the replication, the greater the confidence in the results. However, the analysis in the LANRP is plagued by taking non-independent data points and treating them as though they were independent units, thus making a false claim of replication. When we assume that data points are independent of one another we give data points equal credence and weigh its information as heavily as every other point. If two data points are not independent, then the data set is being treated as though it is larger than it really is and as a result calculating confidence intervals that are too narrow and P-values that are too small.
   - Point count data. – The analysis of data derived from point counts was conducted such that the three counts per year are assumed to be independent (e.g. Pendelton 1995). However, counts conducted in May at a given site are not independent of counts conducted later in the same breeding season at the same site (e.g. the same birds will be counted, and the noise levels are not independent of one another). Data collected from the three count periods within a site should be analyzed separately, averaged so that a mean value per site is used, or alternatively time should be included as a factor in the analysis. For example, in the analysis of Yellow-headed Blackbird density and its relationship to "highway noise", the LANRP lists a sample size of 81 for the linear regression analysis (*see LANRP Table 5, pg. 24*). According to the information I could extract from the LANRP[1] the sample size should only be 28; roughly only *1/3* of what was used in the analysis.
   - Nesting success data. – Information provided within the LANRP suggests that pseudoreplication may have occurred in the analysis of nesting success data. Because standards of statistical reporting were not followed (e.g. Sokal and Rohlf 1981, Whitlock and Schluter 2009), it is difficult to infer how each analysis was constructed. It appears that noise levels were obtained at each nest or at groups of nests and then regressed on

[1] Extracting information on the methodologies and specific results obtained is extremely difficult. Very little data is provided that would allow for an assessment of protocols and methodology. The authors do not follow common practices and standards for reporting the results of statistical tests.

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apparent nesting success. However, the noise levels at nests within a given site are not independent of one another. Furthermore, the success of individual nests at a site are also not independent data points and should not be treated as such in the analysis. Each site will likely have noise levels varying consistently within the site (*see LANRP Results pg. 12*) as well as the same suite of nest predators, and management regime.

2. The LANRP did not address or consider the importance of annual variation in diversity, richness, density and productivity. In most studies, this is often the most striking cause of variation (e.g. Frederick and Collopy 1989, McShea 2000, Schmidt and Ostfeld 2003, Cavitt et al. 2008, Paul and Manning 2008) and yet the LANRP does not even test for the importance of annual variation. Clearly by not attempting to understand how these variables change over time, inferences drawn from the results are suspect.
3. Wetland habitats within the GSL ecosystem differ considerably in their vertical structure. Playa habitats are open and expansive areas with little to no cover, whereas emergent marsh, wet meadow and grassland habitats have significantly more vegetative cover and a much higher vertical structure. The attenuation of sound is likely much different in flat open playas relative to an emergent marsh filled with *Phragmites*. Noise is likely to penetrate and affect avian populations differently depending on the habitat type utilized. Data for the LANRP was collected in each of these different habitat types, but was not addressed or included in the analysis. This coupled with the uneven distribution of habitat types within study sites (see A1 above), suggests another confounding factor that can impact interpretation of results.
4. In order to test the potential effects of highway noise (substituting distance to nearest highway) on avian densities, the authors computed a "combined density estimate" for the 10 most numerous species. The rationale for such a "combined estimate" is not provided nor does it follow any standard practices within the literature. The species included in this estimate are vastly different in their behaviors, life histories, and GSL population sizes. In addition, the authors do not provide information suggesting that no interactions existed between densities of these species and sites. Similarly, it is unclear why only two species (Yellow-headed Blackbird and Common Yellowthroat) were singled out to compare the effects of highway noise on their population densities. The authors should have examined densities of each species rather than selecting just two examples for the analysis. It is not clear why density data were collected on each species if the information is not used to inform the LANRP.
5. Throughout the entire LANRP, detailed information is lacking. This makes any understanding of statistical models and results difficult, if not impossible. The format used by the authors does not conform to any known standard practice of reporting statistical test results.

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C. Study Conclusions and Limitations

Because of the significant problems identified with the design, implementation and analysis of the LANRP, very few conclusions can and should be drawn from the study. The authors themselves identify several weaknesses and also caution the use of the data (*LANRP Discussion pg. 28*). The selection of study sites and the subsequent analyses did not take into consideration known and significant confounding variables. Lack of attention to these factors reduces the value of the study and call into question the results obtained. These confounding variables are detailed above but include the confounding effects of habitat, management and size of each study location. The authors statement that a "lack of significant relationship between distance to highway and bird density suggests that birds are able to inhabit areas close to highway corridors." (*LANRP Discussion pg. 28*) is imprecise and misleading. The authors have failed to account for significant confounding variables and significant sources of variation that likely reduced the ability to detect differences. In addition, the authors only compared the 10 most abundant species, which in itself biases the data set toward the most widespread species. Widespread and common species may not be the ones most likely affected by highway noise.

The selection of focal species for the productivity analyses was not explained and appears to have ignored important aspects of their life histories, and behaviors which suggest they may not have been appropriate choices for study. In addition, the extremely high proportion of nests monitored with unknown fates (20% overall and over 40% at one site) effectively eliminates the information provided by this portion of the study.

D. Minor Comments

Although the following comments are minor in scope, they are included below.

1. The scientific name for Snowy Plover is incorrect within the LANRP (*LANRP Methods pg. 7*). The correct name is *Charadrius nivosus*.
2. WMAs are misidentified throughout the LANRP as "Wildlife" Management Areas. The correct name is "Waterfowl" Management Areas.
3. The LANRP provides insufficient information on all aspects of the project. This makes it difficult for any interpretation of results. For example, study sites are not adequately described in report. The reader isn't provided with even the most basic descriptive information about each site's size, habitat, and management regime. Unfortunately, this lack of attention to detail is not limited to the study site descriptions. There is a lack of information on all methodology (float schedules for aging eggs, how these were calibrated etc). There is no indication of how the number of point count stations per site was determined. Even though the density of avian populations was a key feature in the analyses, these density estimates were never provided for species and sites.
4. The results of regressions describing the relationships between species diversity, and species richness and highway noise were indicated as significant (*LANRP Results pg 20*).

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However, the direction of this relationship is not indicated. This result seemed to be an important finding and yet no discussion of this was ever made.

<u>**Section 2. Specific Questions Addressed**</u>

1. *Synthesize and critique the LANRP.*
   a. *Comment on the "Suggestion For Future Study" and the significance these reported limitations with the study might have on drawing conclusions about the impact of the WDC on the GSL Shorelands Preserve.*

The review and synthesis of the LANRP is outlined in detail within Section 1 above. The authors provide insightful information within the "Suggestions for Future Study" section of the LANRP. I would also suggest that future studies should address the known confounding variables (either through better site selection or adjustments in analyses), and utilize different methodologies for surveying avian communities.

2. *Can valid conclusions about impacts of the WDC on bird species diversity, nesting and foraging in the GSL Shorelands Preserve be drawn from this study?*
   a. *Can impacts to species that nest along the shoreline of GSLSP, but also use the preserve for feeding, be determined from the report.*
   b. *Can impacts to State sensitive species be identified?*

The LANRP reviewed for this project does not provide adequate information that would allow informed inferences to be made regarding the potential impacts of the West Davis Corridor on avian diversity or productivity within the GSLSP. The rationale for this statement is provided in detail in Section 1 above and summarized below. The LANRP did not consider or evaluate the importance of sites for foraging birds nor populations that rely on sites such as the GSLSP during migration.

In general, the LANRP did not adequately select sites that would eliminate confounding variables. This is most apparent with the inclusion of the GSLSP, which is unlike any of the other sites studied in the LANRP. All of the other sites are managed intensively for water (see Section 1A above), whereas the GSLSP does not manage for open water impoundments. Water management within GSL wetlands requires the use of dikes and water control structures that physically change the landscape from its natural condition. The result of intensive water management is a mosaic of fragmented wetland habitat types within close proximity to one another. The landscape within the GSLSP is very different from this type of managed wetland. At this location wetland habitats intergrade with one another and there is an absence of sharp, harsh habitat edges. In addition, the WMAs have instituted management plans specifically designed to enhance waterfowl abundance and productivity. This is not the case at the GSLSP where waterfowl are considered important but not the focal taxon. WMAs also have an intensive predator management program which is not the case within the GSLSP. Predators are managed within the GSLSP but at a lower level than within the WMAs. The GSLSP is also unique in that a substantial portion of the habitat lies within upland sites (i.e. wet meadow and grassland). These areas are critical

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habitat for foraging aquatic birds such as White-faced Ibis, Franklin's Gull, and provide important nesting habitat for upland nesting waterfowl, Long-billed Curlew, and Bobolink.

The LANRP did not address impacts to state sensitive species or those of conservation concern. Although individuals were detected and reported within the LANRP (e.g. Grasshopper Sparrow, Brewer's Sparrow, Bobolink, Long-billed Curlew), no analyses were conducted to determine the impacts of proximity to highways or highway noise on these populations. Productivity data was collected for Snowy Plover, however only 17 nests were located and thus analyses were not possible.

3. *Are the seven study sites used in the LANP, sufficient to make inferences on/in the GSL Shorelands Preserve.*

The design and structure of the LANRP is not sufficient to make inferences to the GSLSP (See Section 2 question 2 above). Significant differences exist between the actively managed wetland sites and GSLSP such that the comparisons are not valid. No other site studied within the LANRP shares habitat and management characteristics with the GSLSP.

4. *Are there any other significant strengths or weaknesses of the report?*

The review of the LANRP is provided in Section 1 above.

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Table 1. Proportion of point-count stations located at each site, within each habitat type (# point-count stations) by minimum distance to nearest highway.

Site	Min Distance to Highway (km)	Emergent Marsh	Grassland	Playa	Wet Meadow
Box Elder Creek Restoration Area	< 1	0.50 (1)	0.00 (0)	0.00 (0)	0.50 (1)
Inland Sea Shorebird Reserve	< 1	0.07 (2)	0.27 (8)	0.67 (20)	0.00 (0)
Farmington Bay WMA	< 1	0.53 (19)	0.00 (0)	0.19 (7)	0.28 (10)
Legacy Nature Preserve	< 1	0.08 (3)	0.69 (27)	0.08 (3)	0.15 (6)
Public Shooting Grounds WMA	< 1	0.26 (10)	0.21 (8)	0.26 (10)	0.28 (11)
Timpie Springs WMA	< 1	0.00 (0)	0.00 (0)	0.63 (12)	0.37 (7)
Salt Creek WMA	2	0.37 (16)	0.35 (15)	0.07 (3)	0.21 (9)
Great Salt Lake Shorelands Preserve	4	0.50 (8)	0.25 (4)	0.06 (1)	0.19 (3)
Locomotive Springs WMA	24	0.80 (4)	0.00 (0)	0.00 (0)	0.20 (1)

WEST DAVIS CORRIDOR

Comment 941 (continued)

Response Section in Chapter 32 ➥

Table 2. Approximate area (ha) of each study location. Data could not be located for Box Elder Creek Restoration Area.

Site	Area (ha)
Box Elder Creek Restoration Area	-
Inland Sea Shorebird Reserve	1468
Farmington Bay WMA	7284
Legacy Nature Preserve	890
Public Shooting Grounds WMA	4703
Timpie Springs WMA	576
Salt Creek WMA	2198
Great Salt Lake Shorelands Preserve	1760
Locomotive Springs WMA	4800

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Comment 941 (continued)

Response Section in Chapter 32 ➥

Exhibit G

Comment 941 (continued)

Response Section in Chapter 32 ➥

466 NORTH 900 WEST KAYSVILLE, UT 84037
877.298.1991
westdavis@utah.gov
www.udot.utah.gov/WestDavis

32.14.3X

Wetland Update Summary
October 2012

Over the past two years, the West Davis Corridor EIS team has collected and analyzed information from much of western Davis and Weber County. Part of that effort has included studying wetlands. This summary will explain what wetlands are, why they are important, how our team has studied them over the course of this project, and how they have influenced the location of alternatives.

What Are Wetlands?

Wetlands are an important natural resource and are federally protected by the Clean Water Act. Besides being a beautiful part of the natural environment, wetlands act as flood control and water storage, as well as filters to help remove harmful contaminants from agricultural runoff, surface water, and ground water. In addition, they serve as habitat for a wide variety of wildlife.

The term "wetland" can be confusing because it does not simply mean land that is wet. To be a wetland, an area must have all of these characteristics:

Water — Water must be present at or near the surface for at least part of the growing season. Wetland scientists use the term "hydrology" when evaluating the prevalence of water.

Soils — Soils must be saturated long enough during the growing season to limit the amount of oxygen available to plants. The types of soil that support this state of saturation are called "hydric soils."

Vegetation — Only certain kinds of plants can thrive in an environment that is frequently flooded and lacks oxygen. The presence of these "hydrophytic plants" indicates the possible existence of a wetland.

The amount of water, the kind of soil, and the types of plants can vary, but a certain combination of all three must be present in order for an area to be classified as a wetland. In order to designate wetlands, scientists throughout the United States use the same set of rules, which are found in the 1987 U.S. Army Corps of Engineers Wetlands Delineation Manual and Regional Supplements. These manuals are recognized as the current authority on wetlands identification by both the Environmental Protection Agency and the Corps.

Comment 941 (continued)

Response Section in Chapter 32 ➥

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Wetland Update Summary
October 2012

Avoid, Minimize and Mitigate

Under Section 404 of the Clean Water Act, any action that places fill material into wetlands (such as building a new roadway) requires a permit from the U.S. Army Corps of Engineers. In order to obtain this permit, agencies must show they have first tried to avoid impacting wetlands. Then, they must demonstrate that they have minimized the amount of wetland impact. Finally, any remaining impacts must be properly mitigated.

History (2010 and 2011 Surveys)

Because wetlands are a federally protected resource, the West Davis Corridor EIS study has included a series of wetland surveys to determine where wetlands are located.

The first survey our team conducted was done at the beginning of the study in the spring of 2010 and looked at the entire study area, from Parrish Lane in Centerville all the way up to 12th Street in Ogden.

Because the study area was so large, wetland vegetation and hydrology were used to define potential wetland areas. This is the common practice around the country for large environmental studies. Once this initial wetland survey was complete, our team was able to proceed with alternatives development.

In February 2011, we had narrowed the possible alternatives down to three, and we shared these alternatives with the public. Many questions arose about the wetland areas we were showing on our maps. Our team was asked to look more closely at several specific areas of concern.

That spring, our biologists were sent into the field again to look more closely at certain areas. This survey was similar to what was done in 2010, looking at hydrology and vegetation. However, we were able to focus more closely on areas near the alternatives.

The 2011 wetland survey found that in some areas, there were more wetlands than we had estimated the previous year. In other areas, there were less wetland areas. These variations occurred because our biologists were able to look more closely in areas around our alternative alignments and not just a general assessment of the entire study area.

Comment 941 (continued)

Response Section in Chapter 32 ➥

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WEST DAVIS CORRIDOR

Wetland Update Summary October 2012

Changes to the Alternatives Based on 2011 Survey

It was because of those changes in wetland areas that we took another look at the alternatives to see where we could make some shifts to further minimize impacts, not only to wetlands, but also to homes and farmland.

One of the areas where we estimated less wetlands was in West Kaysville. Because our new survey data showed less wetlands west of the power lines in this area than we previously estimated, we shifted the alignment to the west side of the power corridor. This shift allowed us to avoid directly impacting 17 homes in the West Kaysville area.

In Syracuse, the data showed more wetlands than we had previously estimated. This increase opened up some new refinements to Alternative B in Syracuse. We made a shift to Alternative B that had similar wetland and home impacts, but saved approximately 40 acres of prime and unique farmland.

Spring/Summer 2012 Survey Work

After our refinements were released, questions were still raised about the wetland survey work. Remember that at that time, the wetland data was based only on 2 of the 3 factors that classify a wetland – hydrology and vegetation. Knowing how critical it was to be certain on the wetland locations, and with the help of additional funding, the West Davis Corridor team decided to look at the 3rd factor in determining a wetland - the soil.

In the spring of 2012, our biologists once again went into the field to assess the wetland areas, but this time they were identifying any areas with hydric soil. In doing so, the biologists dug over 500 test holes to evaluate the hydric properties of the soils in the area.

Through these efforts, it was discovered that many of the areas previously determined to be wetlands did not contain the hydric soil properties to qualify as a wetland.

Our biologists also studied the source of any present water to determine whether it was natural or coming from somewhere else, such as irrigation runoff.

The new revised wetland data is now complete because it includes all three factors that make up a wetland: hydrology, vegetation, and soils. The soil component has proved to be very crucial in the West Davis Corridor study area. Seasonal and irrigation changes can cause yearly fluctuations in hydrology and vegetation, but it takes several years for a soil to develop hydric properties. This means that even though 2012 has been a dry year, it does not cause changes in the hydric properties of the soil.

Comment 941 (continued)

Response Section in Chapter 32 ➥

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westdavis@utah.gov
www.udot.utah.gov/WestDavis

WEST DAVIS CORRIDOR

Wetland Update Summary October 2012

Effects of the Completed Study

With the new wetland data, the West Davis Corridor team has been able to make shifts to the alternatives to further minimize impacts. These alignment changes are available on the project website. The project team will now need to incorporate these new shifts and wetland information into the Draft Environmental Statement (DEIS), which will require additional time.

With these new changes, we anticipate that the DEIS will be released for public review in spring 2013. It is important to remember that no final decisions have been made on an alternative. A final decision will not be made until the study is complete and a final Record of Decision is approved by the Federal Highway Administration in 2014.

Wetland Survey Information for 2010, 2011 and 2012

All of our wetland study information can be found at www.udot.utah.gov/westdavis, under the Documentation Page. Select the Wetland tab to view all our wetlands documentation.

If you have any questions, please contact a member of the public information team by calling the project hotline at 877-298-1991 or sending an email to westdavis@utah.gov.

Comment 941 (continued)	Comment 941 (continued)

Response Section in Chapter 32 ➥

Exhibit H

Response Section in Chapter 32 ➥

Office of the Governor
PUBLIC LANDS POLICY COORDINATION

JOHN HARJA
Director

State of Utah

GARY R. HERBERT
Governor

GREG BELL
Lieutenant Governor

April 26, 2011

Randy Jefferies
Utah Department of Transportation Region 1
166 W Southwell Street
Ogden, UT 84404-4194

Subject: West Davis Corridor
RDCC Project No. 25280

Dear Mr. Jefferies:

The Public Lands Policy Coordination Office (PLPCO) has coordinated a review by other state agencies of this proposed project. Comments from state agencies are listed below for your review.

Division of Water Rights

This project may require a stream alteration permit or a water right. Please contact Dana Dredge at (801) 538-7392 if you need further assistance.

Division of Drinking Water

The division has determined that Alternative A would have the least possible impact on public water supplies/sources because it is almost entirely outside of any source protection zones.

Division of Wildlife Resources

32.14.2H and 32.27J

The Farmington Bay Wildlife Management Area (FBWMA) is an important resource to the state that protects waterfowl habitat and provides public hunting recreational opportunities. This project may result in the loss of some FBWMA lands and/or impact important wildlife resources on the FBWMA. The state requests the Environmental Impact Statement (EIS) provide sufficient information to allow analysis of how the FBWMA may be affected by West Davis Corridor (WDC) construction and operation. Specifically, the state requests the EIS consider:

- Loss of the FBWMA North access for hunting and recreational use of area dikes and marshes.
- Loss of direct public access and recreational use of the FBWMA Nature Center and trails.
- Direct loss of FBWMA property.
- Potential impairment of Utah Division of Wildlife Resources (UDWR) water rights.

WEST DAVIS CORRIDOR

Comment 941 (continued)

Response Section in Chapter 32 ↳

The FBWMA should be considered a U.S. Department of Transportation 4(f) property as it is a publicly owned recreation area, and a wildlife/waterfowl refuge. The FBWMA has significant value to the residents of the State of Utah and construction of the WDC may substantially impair 4(f) uses associated with FBWMA.

Additionally, Glover's Lane is adjacent to FBWMA and the wetland parcels associated with them would be impacted by the Glover Lane alignment. These parcels are mitigation for wetland fill in other locations and the loss of the functional value of these wetlands will also need to be appropriately mitigated. UDWR currently assists with property management of these parcels, as they will ultimately be added to the FBWMA. Wetlands along this alignment should be considered perennial, high value wetlands as they support important habitat for several species of ducks, Canada geese, shorebirds and water birds. Also, the upland fields are important foraging sites for Canada geese and they support nesting populations of ducks and ring-necked pheasants. Bald eagles use winter roost and resting sites along Farmington Creek and other tree sites within this corridor during the winter months. Eagles may be displaced from a loss of these trees or by disturbance from close proximity of the proposed highway. The Glover's Lane alignment will impact 124 acres of wildlife habitat, 8.6 acres of wetlands and 90 acres of floodplain, while the North Shepard Lane alignment option will impact only 14 acres of wildlife habitat, 0.7 acres of wetlands and 2 acres of floodplain. Due to the reduced impacts to wetlands, wildlife habitats and public uses, the division recommends the Shepard Lane option for the WDC connection to I-15. The division recommends the EIS include an analysis of the potential impacts to these habitats for the North Shepard Lane and Glover Lane alignment from potential fragmentation and degradation by this project.

The alignment that begins at Shepard Lane and meanders north along the eastern boundary of the Great Salt Lake (GSL) wetlands to just west of Bluff Road is shared by all 3 alternatives. This alignment would impact approximately 31 acres of diverse wetlands and 276 acres of high quality wildlife habitats. This corridor crosses the Rouche Access UDWR owns and manages for access to recreational marshes adjacent to the GSL. The recreational marshes are owned by The Nature Conservancy and the State of Utah. The state requests the EIS provide sufficient information to allow the analysis of how the Rouche Access and other recreational access points may be affected by WDC construction and operation. In addition, the division recommends a detailed analysis of the other wetlands and wildlife habitat in the corridor focusing on potential impacts from habitat fragmentation and degradation.

Alternatives A and B share a similar alignment from Gentile Street to 5500 South. This area provides habitat for neo-tropical migrant songbirds and provides a nesting and migratory corridor between the wetlands to the west and riparian/wetland habitats to the east. Portions of the Hooper Slough have been identified and zoned as a "nature area" by Hooper City. UDWR receives water drainage flows from the Weber Basin Water Conservancy District, to support wetlands in the Howard Slough WMA and portions of Ogden Bay Waterfowl Management Area (OBWMA) in this corridor. The division recommends analysis of the impact of this alignment to wildlife from fragmentation, loss of drainage flows, and the loss of water flows to downstream wetlands in the EIS.

The arterial alignment of Alternative A begins at 4000 South and continues north to 1200 Street in Ogden. This alignment may impact the Nielson Access road, UDWR's north-eastern access point to the OBWMA. This access area is located at approximately 2550 South and 5100 West and will need to remain available for public and administrative access during construction activities and following any permanent alignment in this location. The division requests the EIS provide sufficient

Page 2 of 3

Comment 941 (continued)

Response Section in Chapter 32 ↳

information to allow the analysis of how this area may be affected by WDC construction and operation.

The wetlands located west of this alignment have been identified as medium quality in the EIS. UDWR's knowledge of these wetlands and observations of wildlife use over time suggests these wetlands should be considered as high quality. The division recommends analysis of this alignment include impact to wildlife from fragmentation, loss of drainage flows, and the loss of water flows to downstream wetlands in the EIS.

The Alternative A alignment with a central option branches off from the shared Alternative A and B alignment near 2700 South in Syracuse and heads north/north-west out into the GSL around the North Davis Sewer Improvement District (NDSID) facility. The EIS should include analysis of the following wildlife concerns:

- Wetlands located north-west of 1700 South should be considered high value wetlands due to their location adjacent to the Great Salt Lake. The majority of this area is an important staging area for raptors, water birds and shorebirds.
- The alignment crosses many wetlands associated with the floodplain of the GSL. The area west of the NDSID supports extremely valuable wetland habitats for water birds.
- The GSL water elevation has been at the level of the discharge point from the NDSID. Any alignment in this area should consider design options to accommodate a high salt water scenario.
- This alignment needs an evaluation of wetland acreage and/or wildlife habitats similar to other alignment alternatives including the impoundments created by the Nature Conservancy.

For all alignment alternatives the EIS should address the following issues and concerns:

- Degradation of wetland water quality from potential contaminant drainage into wetlands from items such as petroleum products, anti-freeze, ice-melting chemicals, vehicle spills, etc.
- Impacts to shallow groundwater aquifers that support downstream wetlands.
- Direct, indirect and cumulative impacts to wetlands and wildlife and their habitat including fragmentation of wetlands and wildlife habitats, hydrological impacts to GSL, noise impacts, and lighting impacts.
- Increased potential for noxious weed establishment and trash accumulation.

The State of Utah appreciates the opportunity to review this proposal and we look forward to working with you on further analysis of this proposal. Please direct any other written questions regarding this correspondence to the Public Lands Policy Coordination Office at the address below, or call Judy Edwards at

Sincerely,

John Harja
Director

Page 3 of 3

Comment 941 (continued)	Comment 941 (continued)

Response Section in Chapter 32 ➥

Exhibit I

Response Section in Chapter 32 ➥

With UWIN we all win.

Utah Wildlife & Conservation Foundation
PO Box 16911
Salt Lake City, UT 84116-6911
P 801.726.7817

March 25, 2011

Mr. Randy Jefferies
Utah Department of Transportation
466 N 900W
Kaysville, Utah 84037

Dear Mr. Jefferies:

32.2.13C Utah Wildlife in Need is **ardently opposed** to the Western Farmington, South Option for the West Davis Corridor. We strongly encourage UDOT to designate the Shephard Lane Connection as their preferred alignment.

Placement of the West Davis Corridor on the West Farmington, South Option alignment will **severely impair the wildlife and recreational values** of the Great Salt Lake Nature Center at Farmington Bay Waterfowl Management Area (Nature Center) and diminish its worth.

Annually the Nature Center serves the needs of over 20,000 students and visitors from along the Wasatch Front and numerous states and foreign counties. The Nature Center and Farmington Bay Waterfowl Management Area are major destination sites in Davis County and praised for their esthetic, educational, recreational, wildlife and economic values.

UWIN is a Utah based, 501(c)3, public nonprofit foundation. UWIN has provided the financial support for the Nature Center. It raised over a million dollars for the Nature Center's construction and operation. This includes a $160,000 Federal Highway Administration grant that was used to fund the 2010 construction of a 1.5 mile boardwalk and nature trail at the Nature Center.

Sixty of the Nature Center's 300 acres were acquired by the Utah Transit Authority to fulfill their wetlands mitigation obligations for construction of the Front Runner commuter rail line. Placement of the corridor on the West Farmington, South Option alignment may put at risk the mitigation value of this property, constituting reconsideration of the mitigation decision.

www.uwin.org

Comment 941 (continued)

Response Section in Chapter 32 ➥

Page 2
March 31, 2011
Subject:

Again, Utah Wildlife in Need **opposes** the Western Farmington, South Option and strongly encourages UDOT to designate the Shephard Lane Connection as the preferred alignment.

Sincerely,

Robert Hasenyager
Executive Director
Utah Wildlife in Need

Comment 941 (continued)

Response Section in Chapter 32 ➥

Exhibit J

Comment 941 (continued)

Response Section in Chapter 32 ➥

31 MAY 11

WEST DAVIS CORRIDOR

April 27, 2012

Dave Millheim, City Manager
City of Farmington
160 South Main St.
Farmington, UT 84025

32.27A

Subject: Farmington Conservation Easements and West Davis Corridor Project

Dear Mr. Millheim:

The Utah Department of Transportation (UDOT) and Federal Highway Administration (FHWA) request your assistance to help FHWA make a necessary determination about conservation easements the City of Farmington holds on several tracts in the western part of Farmington. FHWA and UDOT are completing an environmental impact statement (EIS) and Section 4(f) evaluation for the West Davis Corridor Project, located in part in Farmington. UDOT is pursuing multiple alternative alignments for this new highway, including some that could affect lands on which you hold a Deed of Conservation Easement. The primary conservation easements in question are the Farmington Meadows easement, signed by Mayor Scott Harbertson 10/12/2007; the Farmington Ranches phase 6 easement, signed by Mayor David Connors 12/22/2005; and the Buffalo Ranch easement signed by Mayor Connors 7/2/2003. FHWA, as a potential funder of the project, is required to determine if certain park, recreation, or wildlife refuge lands are protected by federal transportation law known as "Section 4(f)." Section 4(f) is so called for the section of the U.S. Department of Transportation Act in which it originated. It now is codified at 23 USC 103(c) and further detailed in FHWA regulations at 23 CFR 774. Your assistance as the owner and manager of the conservation easement will be appreciated.

To qualify for Section 4(f) protection, a property must be publicly-owned. If it is a park or recreation area, it must be open for use by the general public. If it is a waterfowl or wildlife refuge, it generally would be open to the public unless restricted specifically to protect wildlife resources. The law also applies to historic or archaeological properties on or eligible for the National Register of Historic Places, but that seems unlikely to apply to these conservation easements. Finally, the property must be a "significant" park, recreation area, or wildlife refuge.

Significance. FHWA has a Section 4(f) policy paper that states:

> *The meaning of the term "significance," for purposes of Section 4(f), should be explained to the official having jurisdiction. Significance means that in comparing the availability and function of the park, recreational area or wildlife and waterfowl refuge, with the park, recreation or refuge objectives of the community of authority, the resource in question plays an important role in meeting those objectives.*

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Comment 941 (continued)

Response Section in Chapter 32 ➥

Dave Millheim
April 27, 2012
Page 2of 3

Public Ownership. It is our understanding that the conservation easement is "publicly owned" by the City of Farmington, and that the conservation easement terms are managed through the City of Farmington.

Public Access. It is our understanding through the easement language that the land is available in designated areas, as illustrated on the respective exhibits attached to each easement, for public recreational use and/or community open space.

Park, Recreation Area, or Wildlife or Waterfowl Refuge. The easement language is similar for these conservation easements. The purposes statement is identical:

> *The purpose of this Easement is to assure that the Property will e retained forever in its natural, scenic, agricultural and/or open space condition and to prevent any use of the Property that will significantly impair or interfere with the conservation values of the Property. Any use of the Property which may impair or interfere with the conservation values, unless expressly permitted I this Easement, is expressly prohibited. Grantor agrees to confine use of he Property to activities consistent wit the purposes of this Easement and preservation of the conservation values of the Property.*

The "Recitals" sections of the respective conservation easements have only minor variations. The following example is from the Farmington Meadows easement:

> *WHEREAS, the Property possess unique, sensitive, natural, scenic, aesthetic, open space, wildlife, ecological, floodplain, riparian communities and/or wetland values (collectively referred to as "conservation values") of great importance to the Grantor, the Grantee, and the Public; and*
> *WHEREAS. Grantor intends that the conservation values of the Property be preserved and maintained by continuation of use of the Property in such a way which does not significantly impair or interfere with those values and which provides for appropriate natural, ecological, agricultural, open space and recreational uses of the Property....*

The Farmington Ranches phase 6 and Buffalo Ranch easements leave out "aesthetic" and "ecological" values and add "farm" values in the first paragraph. Both of these easements also "provide for" "educational" uses and do not provide for "natural" uses in the second paragraph. All the easements mention recreation and wildlife.
Our understanding from the Farmington City 2011 Official Zoning Map is that these areas are zoned as AA, "Agricultural, Very Low Density." On the city's 2011 General Land Use Plan map, they are noted as DR, "Development Restrictions, Very Low Density, and/or Agricultural" and not as PPR, "Public/Private Recreation, Open Space, and/or Parks, Very Low Density." Buffalo Ranch trails show on the city's trail map.

Section 4(f) does not protect agricultural land and only protects those portions of multiple-use lands that are designated for or function as significant public parks, significant public recreation areas, or significant public wildlife or waterfowl refuges. The easement language quoted above could be construed as protecting the lands for recreation area purposes or wildlife refuge purposes, or possibly for park purposes. The easements allow for construction of certain trails, and it is our understanding that substantial public-use recreation trails do exist on the Buffalo Ranch property. Less clear is the intent and management of general conservation portions of these easements.

Please provide a written response to this letter by May 11, 2012. In it, please address the following:

1. Does the City of Farmington, as the public body with jurisdiction over the Farmington conservation easements, considers these lands and easements, or delineated portions of them, to be publicly-owned parks, recreation areas, or wildlife/waterfowl refuges? Please provide any documentation of their designation or management for these purposes.

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WEST DAVIS CORRIDOR

Comment 941 (continued)

Response Section in Chapter 32 ➥

Dave Millheim
April 27, 2012
Page 3of 3

2. Does the City of Farmington consider these lands, or delineated portions of them, to be "significant" (as defined in the quote above) as a parks, recreation areas, or refuges?
3. How and by which department does the City manage or oversee these lands and terms of the easements?
4. What group or organization actively manages the land for the purpose stated in the conservation easements?
5. How are the conservation easements currently used?
6. How does the City view the similarities and differences among the easements (including mentions of agriculture, trails, recreation, and wildlife), the City's land use plan, and the city's zoning plan? Are other parks or conservations areas in the City designated with the same zoning and land use as the conservation easements?
7. Are the conservation easement lands, or delineated portions of them, specifically open to the public or closed/restricted?
8. Are there designated areas within the easement lands that are specifically planned to be developed for park, recreation, or waterfowl/wildlife refuge purposes? Please provide any documentation showing official intent to develop these lands for such purposes.

Please don't hesitate to call Vince Izzo at if there are questions. Thank you for your assistance.

Sincerely,

Vincent J. Izzo

Vincent Izzo
HDR Engineering
West Davis Corridor Consultant Project Manager

cc: Project File
Paul Ziman, FHWA

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Comment 941 (continued)

Response Section in Chapter 32 ➥

Exhibit K

Comment 941 (continued)

Response Section in Chapter 32 ➥

FARMINGTON CITY

SCOTT C. HARBERTSON
MAYOR

JOHN BILTON
CORY R. RITZ
CINDY ROYBAL
JIM TALBOT
JAMES YOUNG
CITY COUNCIL

DAVE MILLHEIM
CITY MANAGER

May 11, 2012

Vincent Izzo
HDR Engineering
West Davis Corridor Consultant Project Manager
466 North 900 West
Kaysville, Uth 84037

32.27A Mr. Izzo:

I received your request for a written response to eight questions presented in your letter to me dated April 27, 2012. Thank you for taking the time to seek Farmington City's input regarding the large tracts of open space preserved on the west side of our community. Your questions are set forth below, with my response following each question:

1. Does the City of Farmington, as the public body with jurisdiction over the Farmington conservation easements, consider these land and easements, or delineated portions of them, to be publicly-owned parks, recreation areas or wildlife/waterfowl refuges? Please provide any documentation of their designation or management for these purposes.

Yes. The public owns the easements, they are under the ownership of Farmington City. The City acquired these easements through in-kind compensation of comparable value by substantially increasing in the number of lots available to the then existing property owners for their proposed developments. Our records show that three conservation easements (please see attached documents), and soon to be a fourth, encumber the ground in the path of the proposed westerly alignment of the West Davis Corridor (WDC) [note: the conservation easement for the Hunters Creek development will be recorded soon and will be similar to the others].

Each easement, as expressly stipulated therein, possesses unique and sensitive natural scenic, open space, wildlife, farmland, floodplain, and/or wetland conservation values, and was recorded for the purpose of preserving and maintaining these uses. Publicly-owned parks, recreation areas or wildlife/waterfowl refuges are allowed within the easement area. Presently, for example, the City has an improved trail approximately 3 miles in length (and additional 1.3 miles of trail soon to be improved) available to the public across all three easements and the yet be recorded 4th easement.

Farmington City is legally responsible and must expend public monies to enforce violations of the easement and ensure that parks, recreation areas or wildlife/waterfowl uses of the easement are still available to the public (see enclosed easements). The City has taken such enforcement action in the past when debris has been dumped on the property, when property owners have desired to encroach on conservation land with buildings or unauthorized improvements, or to construct buildings beyond what the easements would allow, etc.

160 S MAIN · P.O. BOX 160 · FARMINGTON, UT 84025
PHONE (801) 451-2383 · FAX (801) 451-2747
www.farmington.utah.gov

Comment 941 (continued)

Response Section in Chapter 32 ➥

2. Does the City of Farmington consider these lands, or delineated portions of them to be "significant" (as defined in the quote above) as parks, recreation areas, or refuges?

Yes. The lands are significant due to their location along the shore of the Great Salt Lake, and their unique conservation values previously mentioned, and the lands are identified on the City's Resource and Site Analysis Plan (an element of the City's General Plan) and must be preserved for such things as parks, recreation areas or wildlife/waterfowl refuges. The lands are also significant because of the magnitude of the size of area that they encompass. They cover hundreds of acres.

3. How and by which department does the City manage or oversee these lands and terms of the easements?

AND

4. What group or organization actively manages the land for the purpose stated in the conservation easements.

The Farmington City Community Development Department, with the assistance of its legal consultants, enforces and oversees the lands in terms of the conservation easements, and the City's Public Works and Parks and Recreation Departments, and the City's Trail Committee, manage and oversee these lands in terms of trail use. A "Trail Boss" (or in certain circumstances more than one trail boss) is assigned by the Trails Committee to walk and inspect the trails/lands on a regular basis.

5. How are conservation easements currently used?

Recreation (trails), natural scenic open space, wildlife habitat, farmland, floodplain and wetland preservation, and green space, preservation of streams, stream corridors, and water courses.

6. How does the City view the similarities and differences among the easements (including mentions of agriculture, trails, recreation and wildlife), the City's land use plan, and the city's zoning plan? Are other parks or conservation areas in the City designated with the same zoning and land use as the conservation easements?

I will answer this question in three parts because it appears that one can construe the first question in this section regarding "similarities and differences" in two ways. Section A and B below deal with the first question and Section C is in response to the question in the last sentence.

A. Similarities and differences among the easements, the land use plan, and zoning [ordinance]: The easements, the City's land use plan (or General Plan), and the city's zoning plan (or Zoning Ordinance) are similar in purpose and function. Farmington views no differences in purposes among the three documents. They are extremely compatible.

All the easements were obtained consistent with purposes set forth in Section 11-12-010 of the Farmington City Municipal Code including, among other things, 1) "conservation of open space land, including those areas containing unique or natural features such as meadows, grasslands, tree stands, streams, stream corridors, flood walls, berms, watercourses, farmland, wildlife corridors and/or habitat, historical buildings and/or sites, archeological sites, and green space, by setting them

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aside from development"; 2) "provide incentives for the creation of greenway systems and open space within the City for the benefit of present and future residents"; and 3) "create neighborhoods with direct visual and/or recreational access to constrained sensitive and conservation land".

The purposes of this Section of the Municipal Code (as well as the easements) are consistent with goals, objectives, policies of the General Plan. These include, but are not limited to the following: 1) "The Farmington City General Plan is based on the overall goal of creating within the community a healthy, attractive, and pleasant living environment for its residents. This is the most significant element underlying the General Plan", 2) "Maintain Farmington as a community with a rural atmosphere, preserving its historic heritage, and the beauty of the surrounding countryside", 3) "Develop a trails system in the City which includes bike paths, jogging/hiking trails, and equestrian trails, etc.", 4) "Explore the potential of preserving open space and greenbelt areas for recreation purposes and for use as buffer zones in developed areas where appropriate and cost efficient", 5) "Encourage the maintenance of farmland and other open lands if they are historically or environmentally unique", 6) "The acquisition and development of open space and park property should be a priority of the Capital Improvement Program", 7) "Continue to conserve conservation and open space land including those areas containing unique or natural features such as meadows, grasslands, tree stands, streams, stream corridors, flood walls berms, watercourses, farmland, wildlife corridors, and/or habitat, historical buildings and/or archeological sites, and green space by setting them aside from development", 8) "Foster an environment within the City in which agriculture lands can co-exist in urbanized areas", 9) "Explore alternatives for preservation of agriculture lands as open space through purchase, lease, conservation easements, or otherwise", and 10) "Maintain Farmington as a predominately low density residential community".

As mentioned previously the easements also protect sensitive land resources identified on the City's Resource and Site Analysis plan, and element of the City's General Plan.

B. Similarities and differences among the easements. The three existing conservation easements include the easement recorded in conjunction with the Farmington Meadows Phase 1 Subdivision dated October, 12, 2007, the easement associated with Farmington Ranches Phase 6 dated December 22, 2005, and the easements regarding the Buffalo Ranch project dated July 3, 2003. All easements were recorded for the purpose of preserving and maintaining the same unique and and sensitive natural, scenic, open space, wildlife, farmland, flood plain, and/or wetland values; and three additional values were contained in the recitals to Farmington Meadows easement: aesthetic, ecological, agriculture and recreational values [note: the other easements mention farmland but the Farmington Meadows easement does not]. It is anticipated that the soon to be established easement with the Hunters Creek subdivision will be recorded with similar purposes.

The first two easement primarily encompass wetlands and wildlife habitat with some acreage available for pasture and farm land. Meanwhile, the Buffalo Ranch Easement constitutes a horse farm, with several out-buildings. Nevertheless, this easement also includes significant areas of wetlands and wildlife habitat. All three easements include flood plains, natural and scenic areas, and open space. Public recreational opportunities including but not limited to, hiking, bicycling, bird watching, equestrian uses, etc., are also prevalent to all three easements.

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C. Yes, there are other parks or conservation areas in the City designated with the same zoning and/or land use as the conservation easements. These include, but are not limited to 1) the public trail and quasi-public park in the Hunter's Creek subdivision, 2) the public park in the Spring Creek Estates subdivision, 3) the public park and public trail system in the Farmington Ranches subdivision, 4) the public trail and board walk system in the Farmington Greens Planned Unit Development, 5) the addition of public park property to the Farmington Pond park, 6) public trails and trail access/trail heads in the Deer Pointe, Shepard Heights, Oakwood Estates, Compton's Pointe, Farmington Manner, Silverwood, Farmington Ranches, Farmington Ranches East, Chestnut Farms, Eagle Creek, Miller Meadows, Deer Hollow, Sunset Hills, Mountainside, Hughes Estates, Tuscany Cove, Tuscany Village, and Willow Creek subdivisions/PUDs.

7. Are the conservation easement land, or delineated portions of them, specifically open to the public or closed/restricted?

Yes, portions of the conservation easement lands are open to the public. The easements contain the Great Salt Lake Shoreline Trail, a segment of the City's Trail Master Plan, an element of the Farmington City General Plan. Approximately, 3 miles of this trail are improved with 1.3 miles still to be developed.

8. Are there designated areas within the easement lands that are specifically planned to be developed for park, recreation, or waterfowl/wildlife refuge purposes? Please provide any documentation showing official intent to develop these lands for such purposes.

Yes, these areas include the trail system as discussed above. Enclosed for your review are photos of the trail. Copies of the easements enclosed herein also delineate the trails.

Thank you for your efforts regarding the EIS for the WDC. If you are in need of further information, please contact me a[redacted] or contact our Community Development Director, David Petersen at [redacted] or by email at [redacted]

Sincerely,

Dave Millheim
City Manager

cc: Mayor and City Council

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Exhibit L

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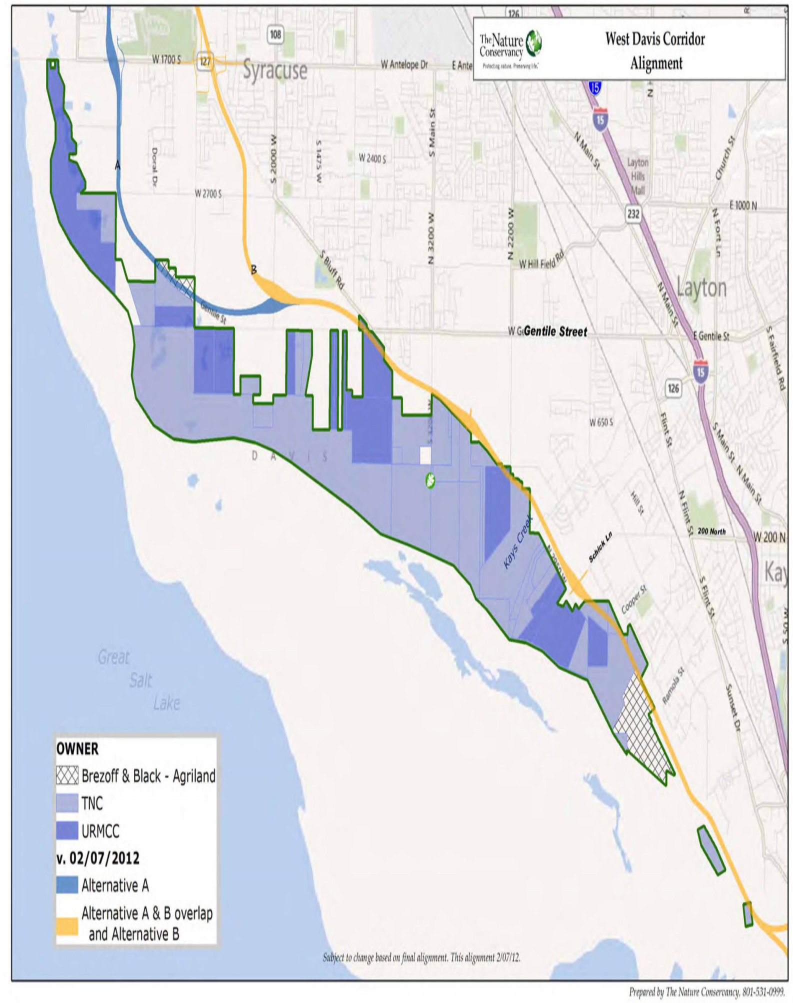

Comment 941 (continued)

Response Section in Chapter 32 ➥

Exhibit M

Comment 941 (continued)

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UTAH RECLAMATION
MITIGATION
AND CONSERVATION
COMMISSION

230 South 500 East, Suite 230, Salt Lake City, UT 84102-2045
Phone: (801) 524-3146 Fax: (801) 524-3148

February 11, 2010

Mr. James Christian, Division Administrator
Federal Highways Administration
2520 West 4700 South, Suite 9A
Salt Lake City, Utah 84118

32.27B Subject: HDA-UT: West Davis Corridor Environmental Impact Statement

Dear Mr. Christian:

Thank you for inviting the Mitigation Commission to participate in the West Davis Corridor Environmental Impact Statement (EIS). Our interest in this project stems from the fact that lands acquired by our agency in the name of the United States of America (USA) are located within the corridor study area. These lands were acquired pursuant to the Reclamation Projects Authorization and Adjustment Act of 1992 (Public Law 102-575, as amended).

Titles II through VI of the Reclamation Projects Authorization and Adjustment Act contain the Central Utah Project Completion Act (CUPCA). The CUPCA provides for an orderly completion of the Central Utah Project (CUP), the largest participating project of the 1956 Colorado River Storage Project, by authorizing an increase in the original appropriations ceiling for CUP. Titles III and IV specifically address fish, wildlife, and outdoor recreation mitigation and conservation responsibilities. Section 306(a) of the CUPCA authorizes the mitigation and conservation activities undertaken by the Mitigation Commission on the lands within the West Davis Corridor study area. These lands acquired by the USA are committed to a public purpose – the mitigation and conservation of wetlands and wildlife habitat.

It should be noted that the mitigation and conservation value of these lands is strongly tied to their adjacency and proximity to The Nature Conservancy's Great Salt Lake Shorelands Preserve (GSLSP). For this reason, activities that would diminish the wetland and wildlife values of proximal lands within the GSLSP would also affect the wetland and wildlife values of the mitigation and conservation lands owned by the Mitigation Commission.

If mitigation and conservation lands owned by the Mitigation Commission, or proximal lands within the GSLSP, may be impacted by the new transportation facility, then we request that the Mitigation Commission be included as a Cooperating Agency for the EIS, as we would be required to complete NEPA evaluation for our actions. However, if you can assure us that neither the Mitigation Commission owned lands nor the proximal GSLSP lands will be affected by the project, then we would request that we be a Participating Agency for the EIS.

Comment 941 (continued)

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Sincerely,

Michael C. Weland
Executive Director

cc: Mr. Paul Ziman, Federal Highway Administration
Mr. Randy Jeffries, UDOT
Mr. Reed Soper, UDOT
Ms. Sue Lee, HDR Engineering
Mr. Dave Livermore, The Nature Conservancy
Mr. Chris Montague, The Nature Conservancy

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